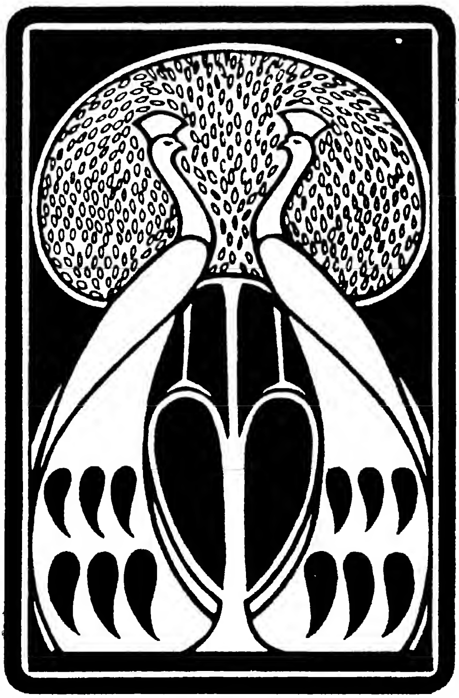
THE NATURAL HISTORY OF ANIMALS

The Animal Life of the World in its Various Aspects and Relations



4 VOLUMES

J.R. Ainsworth Davis

The
Natural History
of Animals

BEAVERS (*Castor fiber*)

The Beaver has a wide distribution in the temperate parts of Europe and North America, though its numbers are rapidly diminishing on account of the merciless way in which it has been hunted down for the sake of its pelt This furnished the material from which top-hats and the like were originally made Originally dwelling in a simple burrow scooped out in a river-bank, the animal has gradually evolved into a skilled architect, capable of constructing a dam across the course of a stream, the framework consisting of the trunks and branches of trees felled by the powerful incisor teeth Upon the dam rounded dwellings or "lodges" of mud are constructed, with openings well below the water level The broad flattened tail is a swimming organ, and is not used as a trowel as often stated.

The Natural History of Animals

The animal life of the world in its various aspects and relations

IN FOUR VOLUMES

BY

J.R. AINSWORTH DAVIS

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NATURAL HISTORY

NERVOUS SYSTEM AND SENSE-ORGANS

CHAPTER LVII

GENERAL PRINCIPLES—NERVOUS SYSTEMS OF INVERTEBRATES AND VERTEBRATES

GENERAL PRINCIPLES

Some of the properties of living matter or protoplasm have already been pretty fully considered, in sections which may be regarded as expansions of part of the brief sketch of Human Physiology given in vol. i, pp. 24–59. We have seen that protoplasm is a very complex and eminently unstable substance, which is continually breaking down into simpler compounds, with the result that stored or potential energy is transformed into actual or kinetic energy, without which movement and other life-manifestations would be impossible. The breaking-down process ultimately results in the formation of waste products, which being physiologically useless are cast out of the body. One such product is carbonic acid gas or carbon dioxide, and a primary object of Breathing or Respiration is to get rid of this. But Breathing also includes the taking in of free oxygen, without which the breaking down of the complex body-substance would not take place at the rate necessary for liberating the energy required. We have also seen that the gradual wasting of the body associated with the breaking-down process requires to be made good; hence the necessity for Food, which is built up into fresh protoplasm. In cases where Growth is taking

place the food taken in must obviously be larger in amount than when it is merely a question of compensating for waste. By a process of over-growth with subsequent separation from the parent-body new individuals are developed, capable of leading independent existences, and ultimately giving rise to a further generation in their turn. Another very characteristic property of protoplasm is Contractility, *i.e.* spontaneous change of shape. Hence all the various kinds of Animal Movement, without which food could not be secured, enemies escaped, or unfavourable surroundings quitted.

The present section is an expansion of the last part of the brief sketch of Human Physiology already mentioned, *i.e.* the part headed Nervous System and Sense Organs. What these are, and why they should exist, cannot be understood without reference to another fundamental property of protoplasm, which we may broadly term Sensitiveness and Spontaneity, there being, unfortunately, no briefer way of putting it. The surroundings of an animal are constantly changing; all sorts of external agents are continually acting upon it to varying extents; and life wholly depends upon successful adjustment or adaptation to this perpetually altering Environment. Alternations of day and night, succession of seasons, tidal flow and ebb, variations of food-supply, the diminution or increase in number of enemies, may be taken as examples of changes which have much to do with the preservation or extinction of old species and the evolution of new ones. That protoplasm is *sensitive* means that it is not inert to its surroundings, but reacts, in ways which tend to the preservation of life, to the influences which are constantly affecting it. If, when you are not looking, someone touches your hand with a red-hot poker, the member thus treated is drawn back without the exercise of will-power, and immediately after a painful sensation is experienced. This practically illustrates the fact that human protoplasm is sensitive to one external agent, *i.e.* heat, and the usefulness of reaction is sufficiently obvious. If animals were not sensitive to heat many of them would very quickly perish in an untimely manner. And a little consideration will make it apparent that Sensitiveness to a great variety of external agents is absolutely necessary to existence. All actions, however, are not the direct results of external agents acting for the time being. Protoplasm is *spon-*

taneous, i.e. it performs actions which find their starting-point within the body itself, as in the case of many voluntary human actions.

Any change in the surroundings which brings the sensitiveness of an organism into play is technically known as a stimulus (L. *stimulus*, an ox-goad), and stimuli may broadly be classified as mechanical, chemical, thermal, photic, and electrical. The corresponding stimulating agents are pressure, change in chemical nature of the surroundings, heat, light, and electricity, which are scientifically defined as different forms of energy, or, to use the old expression, "force". Protoplasm, like every other kind of matter, may be regarded as made up of excessively minute particles or molecules, much too small to be seen with even the most powerful microscope, which are in a state of constant vibration, throbbing, or to-and-fro movement. The pendulum affords a simple example of vibratory movement. It may further be said that every sort of stimulus is of the nature of a vibration, *e.g.* in a sound-wave transmitted through air the particles of air move in a particular way and at a rate depending upon the pitch of the sound. All the changes that take place in living matter result from modifications in the movement of its molecules, but we are profoundly ignorant of what exactly takes place when, say, a muscle-fibre contracts or an impulse passes along a nerve. The adjustment to surroundings that is necessary for the maintenance of life results from these molecular changes in the body, which take place in response to the action of pressure, heat, light, &c., these themselves being of a vibratory nature, as has already been stated. So far as an animal is "sensitive" to its surroundings it is comparable to a complex musical instrument capable of playing all sorts of tunes with all kinds of variations, in response to external influences of different kind. The reaction of an animal to its environment at any given moment depends upon how external agents are acting upon it at that moment: it is they which "call the tune". If the supposed musical instrument could also play tunes of its own accord, independently of the *direct* action of the surroundings, such tunes might be taken to represent the "spontaneous" actions of an animal.

That Sensitiveness and Spontaneity, as above defined, are essential properties of living matter, may best be realized by

studying a very simple organism, such as the Proteus Animalcule (*Amœba*), which is a particle of comparatively pure protoplasm (fig. 1006). That this creature is sensitive to mechanical stimuli is easily proved by tapping the glass slide on which one is crawling about under the microscope. The protruding lobes of the body (pseudopods) by which creeping is effected will be drawn in, and the animal will assume a spherical form (fig. 1006, A).

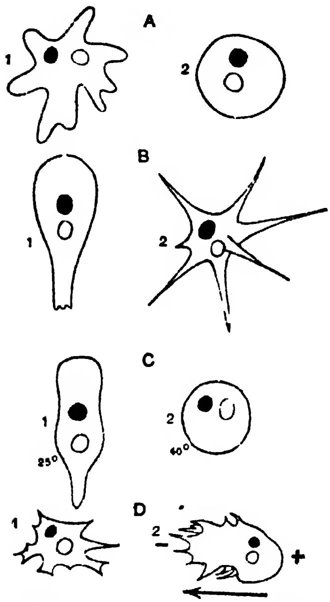


Fig. 1006.—Proteus Animalcules (*Amœba*), much enlarged, showing effect of various stimuli. 1 and 2, Appearance before and after application of stimulus. See text

A good example of chemical stimulation is afforded by the addition of very weak caustic potash to the water in which the slug-shaped species of Amœba (*A. limax*) is moving along, the reaction consisting in this case of the protrusion of long pointed pseudopods (fig. 1006, B). The same kind of Amœba reacts in a marked way to changes of temperature (fig. 1006, C). At freezing point (0° C.) it is spherical and inert; as the temperature increases from 0° C. to 35° C. it moves about with ever-increasing activity; above this the activity gradually diminishes; and at about 40° C. the animal has assumed a spherical form, and dies in a condition of "heat-stiffening" or coagulation. This illustrates very well the fact that any particular stimulus has only a certain range of action, the range in this case being between 0 C. and 40° C., which are known as the *minimum* and *maximum* points of heat-stimulation for this particular animal. Between these two points is an *optimum* one (35° C. in this instance), at which the stimulus exerts its greatest effect by way of promoting activity. Light does not appear to affect the creeping movements of Amœba, but is said to check the taking in of food, which process goes on most actively at night. If a constant current of electricity is passed through the body of an Amœba which is protruding pseudopods in all directions it will begin to creep against the current, and all those pseudo-

pods will be drawn in which are not at the front end for the time being (fig. 1006 D).

Since a hungry Amœba creeps actively about for a long time we are probably justified in concluding that some of its movements are spontaneous, and these are probably initiated by chemical changes which take place within its body, and may be called internal stimuli.

NERVOUS SYSTEMS OF INVERTEBRATES

The Amœba, like most other animalcules, is a single cell or structural unit, which has to discharge all the functions of life, and does not exhibit the principle of division of labour to the same extent as animals belonging to the higher groups, which are collectively termed Metazoa, as contrasted with the Animalcules or Protozoa. Every member of the former group is made up of more or less numerous cells, and may therefore be styled a *cell-community*. It is clear that in such a case advantageous adjustment to the surroundings is best secured on the principle of division of labour, by which the vital activities are shared among the members of the community. Evolution on these lines has resulted in the development of Digestive Organs, Respiratory Organs, Organs of Movement, &c., the complexity of which is very great in some of the higher groups of animals. Hence the need for some means of central control, some way of correlating the diverse parts of the body, and at the same time of adjusting the body to its environment. These duties are discharged by the Nervous System, with the aid of Sense Organs, which keep it in touch with external agents. The Sensitiveness and Spontaneity of a Metazoon, in fact, are more or less centred in the Nervous System and Sense Organs, and this is true to an increasing extent as we consider animals higher and higher in the scale. At the same time it must not be forgotten that every cell in the body is endowed with *all* the primary properties of protoplasm, though cells specialize as it were in different directions, according to the nature of the organs of which they form a part.

NERVOUS SYSTEMS OF ZOOPHYTES (CŒLENTERATA). — The members of this primitive group, comprising Freshwater Polypes (*Hydra*), Hydroid Zoophytes, Jelly-Fish, Sea-Anemones, and

Corals, correspond to a fairly early stage in the evolution of the Metazoa from simple colonies of Protozoa, and furnish us with some idea of the way in which nervous systems have arisen. Reduced to its simplest terms the body of such an animal is practically a living stomach, and is made up of two layers of cells—an inner one (endoderm) and an outer one (ectoderm). We are here more especially concerned with the outer layer. It would appear that the nervous system was first evolved in the interest of adjustment to the surroundings, and it is not therefore surprising to find that it has come into existence by modification of some of the cells making up the ectoderm, since this layer immediately adjoins the outer world. The same is also true for the essential parts of all the sense-organs. These specialized nervous elements are known as *nerve-cells* or *ganglion cells*, which constitute so many centres of correlation and control. A typical cell of the kind is star-shaped and possesses a large nucleus, but it may also be round or ovoid. In Vertebrates, of which our knowledge is considerable, it is usual for a nerve-cell to be prolonged into a number of branching prolongations, and one nerve-fibre, which may be of very great length (fig. 1007). It is convenient to speak of the cell with its extensions as a *neuron*, and investigation will probably show that the neurons of Invertebrates are broadly similar to those of Vertebrates, though in many instances our knowledge is here very incomplete. It is clear that the nerve-cells need to be in communication with the environment, the parts which they control or correlate, and other similar cells with which they co-operate. This is provided for by the slender extensions of the cell-body, which constitute lines of communication. There is reason to think that the branching extensions are paths of conduction *to* the cell, while the nerve fibre is a similar path *from* the cell. It was formerly believed that the neurons in a nervous system are united together by their processes into a complicated net-work or *plexus*, but it is now known that in Vertebrates at any rate this is not so, though the slender extensions of one neuron are closely adjacent to those of others. The same thing is probably usually true for Invertebrates.

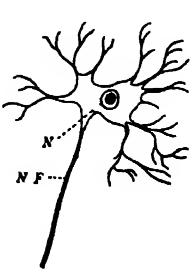


Fig. 1007.—A Typical Neuron, much enlarged. *N*, Nucleus, *N.F.*, nerve-fibre (cut short).

Although neurons belong to the external cell-layer they do not remain at the surface of the body, but sink as it were more or less inwards to take up a more sheltered position, leaving to sense-cells the duty of reception of stimuli from external agents. In some Jelly-Fish we find cells of the external layer which are beginning to sink in to constitute neurons, while others have actually done so and acquired at the same time a more specialized shape (fig. 1008, A).

A nervous system of very primitive kind is found in a Sea-Anemone, which, leading as it does a sluggish life fixed to some firm object, does not require any very elaborate correlating mechanism. There is here a delicate continuous nerve-layer underlying the ectodermal cells that directly adjoin the exterior, and made up of innumerable neurons of which the extensions run in all directions (fig. 1008, B). Even in this case, however, there is a certain amount of centralization, for the nerve-layer is thicker in the upper side of the body where the mouth is placed, and in the tentacles which fringe this region.

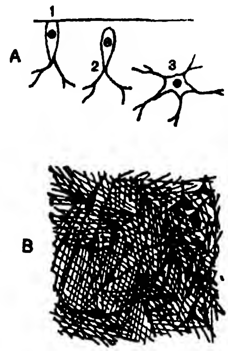


Fig. 1008.—A, Stages in the Evolution of the Neurons of a Jelly-Fish, enlarged. B, Part of the Nerve-Layer in a Sea-Anemone, showing Neurons, enlarged

The free-swimming Jelly-Fish, having more complex adjustments to effect with the environment than their fixed relatives, possess, as might be anticipated, a more centralized nervous system. It is true that there is here also a continuous nerve-layer in the deeper part of the ectoderm, but part of this is concentrated into what may be called a *central nervous system*. This may be either in the form of a double nerve-ring placed near the edge of the umbrella, or it may consist of small masses of neurons placed at regular intervals in the same region.

Nervous Systems of Segmented Worms (Annelida).—The members of this group are comparatively complex in structure, and possess a well-defined nervous system, that conforms to the two-sided or bilateral symmetry of the body. The primitive nerve-layer in the ectoderm is retained more or less, but it is largely superseded by the central nervous system, which consists of a nerve-ring surrounding the front end of the digestive tube, and a double nerve-cord running along near the under

side of the body (fig. 1009). In the lower Annelids this system is closely connected with the ectoderm or outer layer of the skin, but in the more specialized members of the group it has sunk within the muscular layers of the body-wall, where it is much better protected. Connected with these central organs are a large number of slender nerves, that come into intimate relation with the various organs of the body, and are made up of excessively minute nerve-fibres which are prolongations of the nerve-cells. On the upper side of the nerve-ring are two little swellings, that may be regarded as an incipient brain or chief central organ, and are technically known as ganglia. A ganglion is a thickened part of a nerve-cord, where nerve-cells are concentrated as a result of evolution along centralizing lines. The ventral cord swells into a pair of ganglia in each segment of the trunk, for which they act as controlling organs. In such a form as the Earth-Worm the ganglia are not very distinct, and nerve-cells are scattered throughout the whole of the central nervous system, but in the free-living Bristle-Worms and Leeches concentration of nerve-cells has taken place to a much greater extent, and the ganglia are clearly marked. The relations of these active forms to their surroundings are comparatively complex; hence greater concentration of nerve-cells with increased efficiency of the nervous system. The complex nature of the neurons will be gathered from fig. 1010, which represents a few of them in part of the ventral cord of an Earth-Worm.

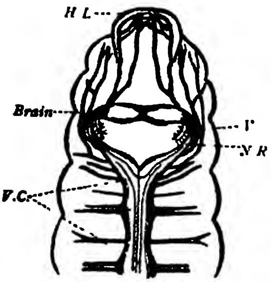


Fig. 1009.—Front Part of the Central Nervous System of an Earth Worm, enlarged. *H L.*, Head-lobe. *N R*, side of nerve-ring. *V*, visceral or sympathetic nerves; *V C.*, ventral cord, giving off nerves, and swollen into indistinct ganglia

The front end of a bilaterally symmetrical animal, such as a segmented worm, is more subject to the action of external agents than the rest of the body, and becomes specialized into a *head*, in which the most important part of the nervous system, *i.e.* the brain, and the chief organs of sense are located. Even in a segmented worm we are justified in considering the brain as the highest part of the nervous system, because it is the chief centre of correlation and administration. Voluntary action, consciousness or awareness of existence, sensation, and intelligence, so far as these exist in so lowly an animal, are dependent upon

it. That this is so in the common earth-worm we know from the fact that the mole stores up these unfortunate creatures as a sort of living larder, having previously bitten off the front ends of their bodies, and consequently removed such brains as they possess. This does not destroy life, but prevents the victims from crawling away. The ventral nerve-cord is subordinate to the brain, but exerts a considerable amount of independent control, each pair of ganglia dominating the ring or segment to which it belongs. To these collections of nerve-cells are due what are technically known as *reflex actions*, which are quite independent of will. We may instructively consider one common sort of reflex action which manifests itself in muscular movement. If the skin of one of the segments is stimulated mechanically, chemically, or otherwise, some amount of contraction in the muscle of the body-wall immediately follows. For the performance of this or any other reflex action three nervous elements are requisite: (1) a nerve-centre consisting of one or more, usually of several, nerve-cells, which in the latter case co-operate with one another; (2) one or more nerve-fibres constituting an *afferent* tract carrying impulses *to* the nerve-centre from sensitive ectodermal cells which have been acted upon by the mechanical, chemical, or other stimulus; and (3) one or more nerve-fibres forming an *efferent* tract carrying impulses *from* the nerve-centre to the executive structures which perform the reflex action, these being muscle-fibres in the case supposed (fig. 1011). Even in ourselves many actions are of reflex nature, *e.g.* the involuntary withdrawal of the hand from a red-hot substance as described on an earlier page (p. 2).

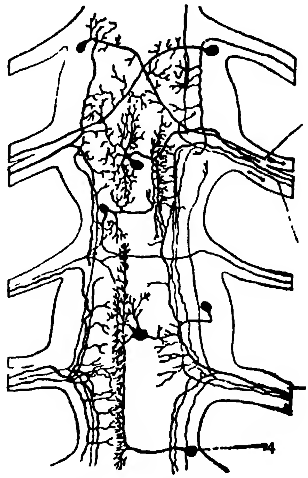


Fig 1010—Diagram of part of the Ventral Cord of an Earth-Worm, showing a few Neurons, enlarged. The two arrows (on the right) indicate the direction of nerve-impulses. 1, Nerve-roots; 2, afferent nerve-fibres; 3, efferent nerve-fibres; 4, a neuron, of which the branches extend through three segments

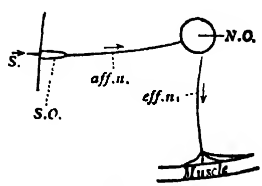


Fig 1011.—Diagram of a Simple Reflex Action. *S*, Stimulus, *S.O.*, sense-organ; *aff.n.*, afferent nerve; *N.C.*, nerve-centre; *eff.n.*, efferent nerve. Direction of nerve-impulses indicated by arrows.

It has already been stated that one of the duties of a nervous system is to correlate the organs of the body itself, and even in an earth-worm there is a special arrangement for controlling the digestive organs, and consisting of nerves which run from the sides of the nerve-ring to the gut, and branch out in a complex way, the branches swelling here and there into extremely minute ganglia. This arrangement is called the *visceral nervous system*, and, like the ventral cord, is subject to the control of the brain.

Before leaving segmented worms one feature in the nerve-cord is deserving of notice. It is distinctly of double nature, and in some cases its two longitudinal halves are widely separated (fig. 1012). In the evolution of this type of nervous system it is probable that each side of the body developed and was regulated by its own longitudinal nerve-cord, and this is actually the arrangement found in the curious unsegmented forms known as Nemertine Worms. Though these constitute a special group quite distinct from Annelids, they are descended from common ancestors, some of the primitive characters of which they have probably retained, one being the possession of a strong lateral nerve on either side, instead of a double ventral cord (fig. 1013). Such an arrangement is not a desirable one, for it means imperfect correlation between right and left sides of the body. The ventral cord of an Annelid has quite likely been derived from lateral cords of the kind, which have migrated downwards and come into more or less intimate relation with one another in the interests of centralization.

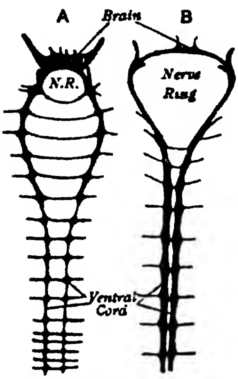


Fig. 1012.—Front Part of Central Nervous System in two Marine Annelids, enlarged. In A the two halves of the ventral cord are fairly far apart, while in B they are close together but not fused. *N.R.*, nerve-ring.

Nervous Systems of Jointed-Limbed Invertebrates (Arthropoda).—There can be little doubt that the members of this huge group have sprung from ancestors which resembled Annelids in many respects. But they have specialized in various ways, partly as the result of centralizing tendencies which have resulted in increased complexity of structure, associated with very perfect adjustment to surroundings. The body, instead of being greatly elongated and made up of a large number of rings or segments, is comparatively short, and composed of relatively few segments.

In the higher members of the group, *e.g.* lobsters and insects, the segments in front have fused into a well-developed head, followed by a thorax, to constitute which other segments have coalesced, while this is succeeded by an abdomen, where the amount of union of segments varies greatly in different cases. These three successive regions of the body differ greatly from one another as to size and shape, and may undergo further fusion. Thus, in a

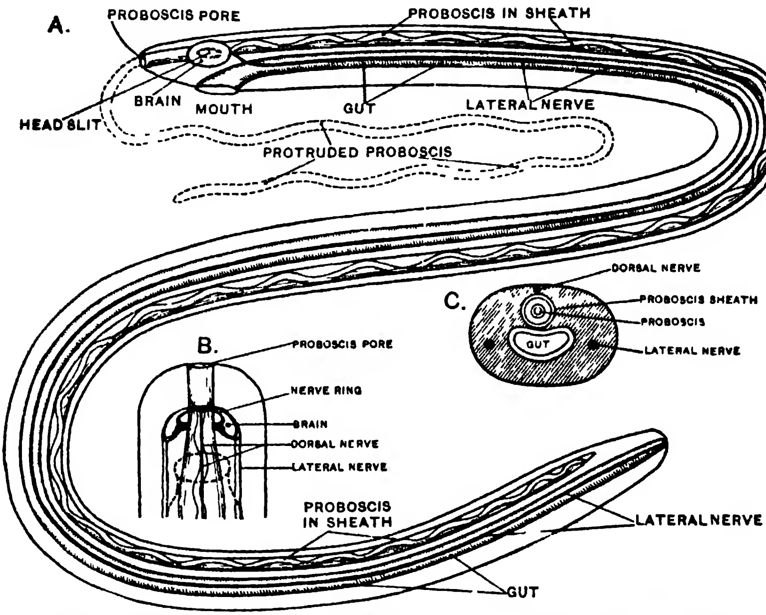


Fig 1013 —Diagrams to illustrate Structure of a Nemertine Worm, represented as a transparent object

A, Side view, B., front end, seen from above, C, cross section

Lobster, head and thorax are welded together, and in a Spider not only is this so, but the abdominal segments have closely united into a rounded mass.

The nervous system of an Arthropod, like that of an Annelid, consists of nerve-ring and double ventral nerve-cord, but the ganglia are better developed, and in the higher members of the group they are more or less fused together into larger nerve-masses, just as the segments to which they belong are similarly united. There is, in other words, an increasing amount of centralization in the nervous system as we pass from lower to higher forms in any subdivision of the Arthropods. And this is clearly

advantageous in regard to correlation of the different parts of the body, and adaptation to the environment. It may also be noted that while in many lower Arthropo ls the two halves of the ventral cord are more or less separate, they are intimately united together in higher forms.

Nervous Systems of Crustaceans (*Crustacea*). — Successive stages of fusion in the nervous system may be illustrated by comparison of Apus, Crayfish, and Crab. In the first of these, which is one of the lower forms, there is a nerve-ring with clearly-marked brain, and a ventral cord of which the two halves are widely separate (fig. 1014). The brain of a typical Annelid, such as the Sea-Centipede (*Nereis*), is lodged in a head-lobe (prostomium) that forms the front of the head and overhangs the mouth, and it supplies with nerves the eyes and feelers which are borne upon this lobe (fig. 1014). The brain of Apus is placed in a corresponding position, and is in the main equivalent to that of Nereis, though probably not entirely so. A Crustacean possesses two pairs of feelers (antennules and antennæ) situated in front of the mouth, but most likely their original position was behind that aperture, and they have shifted forwards into a position more suitable for the work they have to perform, by way of exploring the surroundings. These two pairs of feelers belong to two segments of the head, each of which is provided with a corresponding pair of ganglia. In Apus those of the segment to which the antennæ belong are the first pair of the ventral cord (see figure), but the nerve for each front feeler or antennule arises from the side of the nerve-ring, and can be traced into the brain. This is intelligible if we suppose that organ to be equivalent to the brain of an Annelid, plus the ganglia supplying the antennules, which have shifted forwards along the sides of the nerve-ring. If this view be correct, a certain amount of fusion and centralization has taken place at the front end of the nervous system in Apus, as compared with an Annelid. But it is here necessary to state that

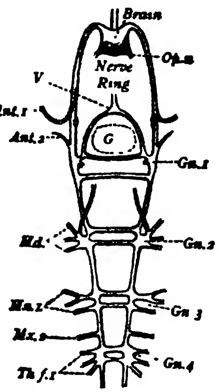


Fig 1014.—Front Part of the Central Nervous System of Apus, enlarged

G, Place where gullet runs through nerve-ring *Gn.1*–*Gn.4*, ganglia of one half of ventral cord, *Op n*, *Ant 1*, *Ant 2*, *Md*, *Mx 1*, *Mx 2*, *Th.f 1*, nerves to eyes, antennules, antennæ, mandibles, first and second maxillæ, and first thoracic feet, *V*., visceral nervous system.

some authorities hold a different view as to the antennules, believing that these have always been situated in front of the mouth, and are in reality outgrowths from the head-lobe. If so they are comparable to the sensitive palps on the head of a Nereis, and the brain of Apus is strictly equivalent to the brain of an Annelid. We shall assume here the truth of the first view, as the balance of evidence is in its favour.

The body of Apus is made up of a comparatively large number of segments, while in Crayfish and Crab, as in all members of the highly-organized group (Decapoda) to which they belong, there are relatively few, *i.e.* twenty, so far as can be definitely made out. Five belong to the Head, eight to the Thorax, and seven to the Abdomen, each with a pair of ganglia and, except the last, provided with a pair of limbs. The nervous system of the Crayfish has undergone a certain amount of fusion and centralization (fig. 1015). The brain is larger and more complex than that of Apus, and it supplies not only the first but also the second feelers, the ganglia corresponding to which have shifted along the nerve-ring. Even greater fusion has taken place at the front end of the ventral cord, where there is a large ventral ganglion, which has resulted from the union of the last three pairs of head-ganglia (supplying the three pairs of jaws), and the three first pairs of thoracic ganglia (supplying the three pairs of foot-jaws). It is interesting to notice that the third thoracic ganglia are caught as it were in the act of uniting with those in front of them. The last five pairs of thoracic ganglia (supplying pincers and walking-legs) are clearly defined, although by reference to the figure it will be seen that the last two are beginning to unite, while just in front of this the doubleness of the cord is practically demonstrated by the fact that its two halves diverge, for the passage of an artery which runs vertically downwards from the heart to supply the ventral region of the body. The first five pairs of abdominal

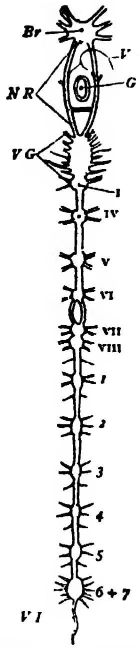


Fig 1015 —Central Nervous System of Crayfish

G, Gullet (in cross section). *Br*, brain. *NR*, side of nerve ring. *VG*, ventral ganglion. III–VIII, ganglia of third to eighth thoracic segments. 1–7, ganglia of abdominal segments. *VA* and *VP*, anterior and posterior visceral nerves

ganglia are quite distinct, and smaller than those of the thoracic region, in correspondence with the relatively small size of their segments. But the last two pairs have united into a somewhat larger nerve-mass, which supplies the last two segments of the body, that include the large tail-fin. It has been shown by experiment that the brain of the Crayfish is the dominating centre of the nervous system, while the remaining nerve-masses are centres of reflex action for the segments which they supply.

Turning now to the Crab, in which the head and thorax are relatively short and broad, and the abdomen insignificant, the brain is comparable to that of a Crayfish, but all the ganglia of the short ventral cord have fused together into a single mass, placed near the under side of the thorax, and perforated by the artery which runs down from the heart (fig. 1016).

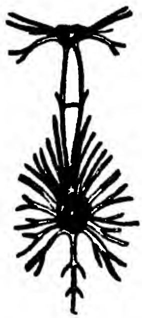


Fig 1016.—Central Nervous System of a Crab The brain forms the thickened front end of the nerve-ring, while the large ventral ganglion is seen behind, with numerous radiating nerves.

In all the three Crustaceans described there is a visceral nervous system, the roots of which are indicated in the figures.

Nervous Systems of Air-breathing Arthropods (Tracheata).—Comparison of Peripatus, Myriapods, Arachnids, and Insects will show that the same lines are followed as in Crustaceans. In the less-specialized forms, where the body is elongated and there has been but little fusion between segments, the nervous system is very like that of an Annelid. But in cases where the body is comparatively short and much fusion has taken place, the nervous system is concentrated to a corresponding degree.

We have already had occasion to see that Peripatus is the most primitive of all living air-breathing Arthropods, and has the closest affinity to Annelids. This view is fully borne out by examination of the nervous system. The upper side of the nerve-ring is swollen into a relatively large brain, and the two halves of the ventral cord are widely separate, though united by numerous transverse bands of nerve-fibres. The outer part of each cord, through its entire extent, contains numerous nerve-cells, and these are not aggregated into well-marked ganglia (fig. 1017).

Myriapods, such as ordinary Centipedes and Millipedes, are rather more specialized than Peripatus, and possess a well-marked

head, although there is no distinction between thorax and abdomen. The central nervous system consists of the usual nerve-ring and double ventral cord, and well-developed ganglia are present, between which the two halves of the cord commonly remain distinct (fig. 1018). In Centipedes there is a certain amount of fusion between the ganglia at the front end of the cord, the region from which spring the nerves of the three pairs of jaws, and also those of the poison-claws.

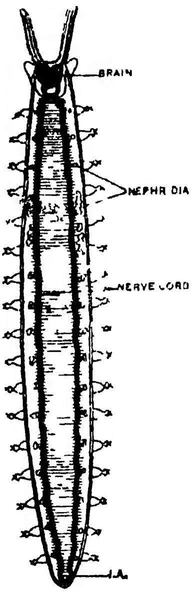


Fig 1017.—Dissection of Peripatus from the upper side, to show Central Nervous System. I.A., Intestinal aperture

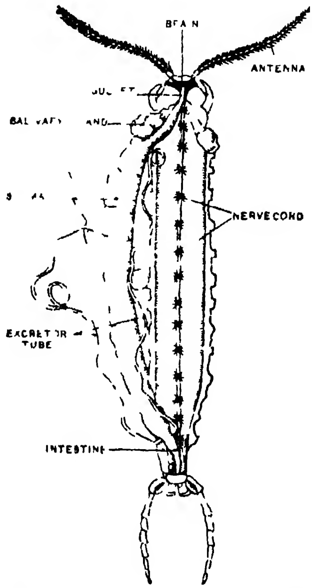


Fig 1018 —Dissection of a Centipede (*Lithobius*) from above, enlarged

In regard to Arachnids, it will be sufficient for our present purpose to remark that the relation between the nervous system of an elongated form, such as a Scorpion, with that of a shortened form, such as a Spider or Mite, is much like that existing between a Crayfish and a Crab (p. 14). For in a Scorpion many of the pairs of ganglia of the ventral cord remain distinct, though there is a good deal of fusion between those at its front end, while in a Spider or Mite all the ganglia of the cord have consolidated into a single nerve-mass.

Among the Insects, again, we find the same principles exem-

plified. Some of the simpler forms possess a nervous system very much like that of a short Centipede, and from this condition all degrees of fusion and concentration are found, the maximum being reached where all the ganglia of the ventral cord have united into a single nerve-mass, precisely as in Crabs and Spiders. Three such stages, as exemplified by a Termite, a Water-Beetle, and a Fly, are represented in fig. 1019. In those insects which begin life as larvæ, it commonly happens that in this early stage of life the nervous system is simpler than in the adult, exhibiting less fusion and concentration. This is exemplified by comparison of a caterpillar with the butterfly or moth which it becomes, or a bee-grub with an adult bee. Cases are known, however, where the nervous system is condensed both in larva and adult, *e.g.* the House-Fly and its allies (*Muscidæ*). A curious reversal of the ordinary state of things is found in the Ant-Lion (*Myrmeleo*), for here the nervous system of the relatively short and squat larva is more concentrated than that of the elongated adult. That this should be so is probably not merely due to difference in shape, for the complex habits of the rapacious larva involve elaborate adjustments to the surroundings, which need an efficient and centralized nervous system for their proper performance (see vol. ii, p. 111). So far as we know, the life of the adult is relatively simple.

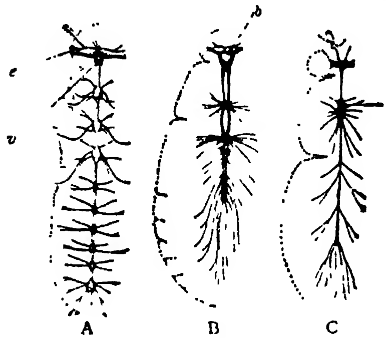


Fig. 1019.—Central Nervous Systems of a Termite (*Termes*, A), a Water-Beetle (*Dytiscus*, B), and a Blow-Fly (*Musca*, C), to illustrate stages in concentration. *b*, brain. *e*, eye; *v*, ventral ganglion

It remains to be added that all the air-breathing Arthropods possess a visceral nervous system, which may attain considerable complexity, and takes origin from the nerve-ring.

NERVOUS SYSTEMS OF MOLLUSCS (MOLLUSCA).—The least concentrated type of nervous system is found, as might be expected, among some of the Primitive Molluscs (Amphineura). The central nervous system of a Mail-Shell (*Chiton*), for instance, consists of a nerve-ring from which four thick nerves run back (fig. 1020). Two of these are *pedal cords*, that traverse the substance of the muscular foot, while the others are *lateral cords*

placed at a higher level, and uniting with one another behind above the intestine. The nerve-cells are distributed pretty uniformly throughout both ring and cords, in the course of which are no distinct ganglia. The pharynx with its rasping organ receives branches from the nerve-ring, which *do* swell into small ganglia, and this is also the case with a pair of nerves running from the lateral cords to the under side of the stomach (see figure). In this sluggish animal digestion is the dominant function, and that is possibly why the only distinct ganglia in the nervous system are related to the digestive organs. The visceral nervous system consists in this case of (1) the nerves which run from the nerve-ring to the pharynx, (2) the lateral cords and their branches.

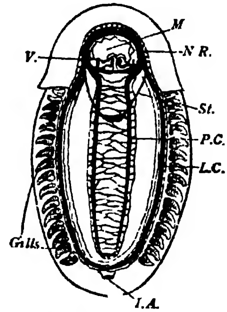


Fig 1020.—A Mail-Shell (*Chiton*) dissected from above, to show Central Nervous System

M., Mouth; *I A.*, intestinal aperture; *N R*, nerve-ring, *P C.*, pedal cord, *L.C.*, lateral cord; *St*, stomach nerve passing back to pair of gastric ganglia; *V.*, part of Visceral nervous system

Passing from a simple form like the Mail-Shell to those which are more specialized, we shall find that as we ascend the scale to higher and higher types the nervous system becomes more and more centralized, in the same sort of way as in Arthropods. The nerve-cells are no longer scattered throughout the central nervous system, but are collected into definite ganglia, of which the most important are thickenings of the nerve-ring. This is very well seen in Snails and Slugs (Gastropoda), a vast number of which present a similar arrangement to that represented in fig. 1021 for the River-Snail (*Paludina*). In the middle of the figure is seen the nerve-ring, which is thickened into three distinct pairs of ganglia —(1) brain-ganglia above, (2) side-ganglia laterally (dotted in the figure), and (3) foot-ganglia below. The brain-ganglia, as shown at the top of the figure, give origin to a cord that supplies the pharynx, and swells into a pair of small ganglia from which nerves run to the pharynx. This is part of the visceral nervous system, the rest of it consisting of a nerve-loop by means of which the

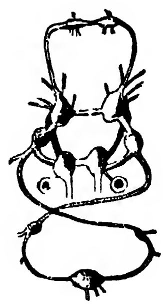
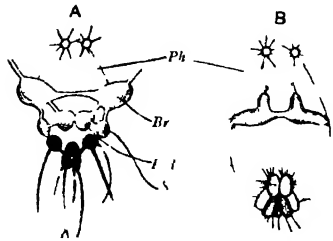


Fig. 1021.—Central Nervous System of a River-Snail (*Paludina*), enlarged See text. The circles shaded in the centre and connected with the pedal ganglia are the so-called "ears" (*Otocysts*)

two side ganglia are connected together, and in the course of which are three ganglia supplying many of the organs of the body As in all Gastropods, the upper part of the body of the River Snail has been subjected to a sort of twisting process as the spiral shell suggests and this has affected the nerve loop making it 8 shaped as shown in the figure This well specialized central nervous system is associated with the presence of a clearly defined head while just the contrary is the case in a Mail Shell Centralization has taken place to a still greater extent in some of the Gastropods, as in the Pond Snail (L[illegible]) and Garden Snail (H[illegible] aspersa, fig 1022) where the nerve loop, which here has not been influenced by the twisting of the body, is so short that the [illegible] are closely pressed [illegible] one another and [illegible] the [illegible] ganglia and side [illegible] ring



F[illegible] —Central Nervous Sy[illegible] [illegible]

Both in Bivalve Molluscs (Lamellibranchiata) and Tusk Shells (Scaphopoda) the nervous system follows the type described for Gastropods, but is less concentrated and the brain ganglia are relatively small which may be correlated with the absence of any definite head in the former group and its imperfect development in the latter

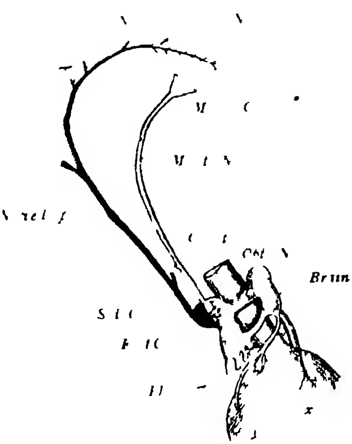


Fig. 23 Central Nervous System of Cuttle Fish (*Sepia*), seen from the right side

[illegible] ganglia V nerve *Ph* [illegible] pharyngeal or buccal ganglia *Osph* V osphradial nerve of water testing organ (*osphradium*)

Among the Head Footed Molluscs (Cephalopoda) various degrees of concentration are found, there being the least amount of this in the Pearly Nautilus, which is a primitive and isolated type, while in the active Cuttle Fishes Squids and Octopi con

tralization is at a maximum. The Common Cuttle-Fish (*Sepia officinalis*, fig. 1023) possesses a nerve-ring of which the ganglia are exceedingly large and closely connected. In one respect the nerve-ring is less complex than that of the Garden-Snail, for it here includes two only of the three ganglia of the nerve-loop, which is long, distinct, and, like the body, not twisted. The nerve-ring of Cephalopods is more or less enclosed in a gristly case, serving as a sort of skull.

NERVOUS SYSTEMS OF BACKBONED ANIMALS (VERTEBRATA)

The nervous system attains its maximum complexity in backboned animals, especially in the highest Mammals. The chief part of the central organs consists of a tube, which is placed near the upper side of the body, and in all but the lowest members of the group is sheltered within a skull and backbone. The front end of this nerve-tube is usually swollen into a brain, which is the chief organ of correlation and adjustment, while the rest of it is known as the spinal cord or spinal marrow. The central structures also include a visceral, or, as it is here usually called, a sympathetic nervous system, which where best developed consists of a couple of cords running longitudinally near the under side of the backbone, and swelling at intervals into sympathetic ganglia. Besides these there are outlying ganglia of similar nature in close connection with some of the internal organs, and connected with the cords just mentioned.

The body of a Vertebrate is undoubtedly made up of rings or segments, and although this is not at first sight apparent, the serial arrangement of certain structures shows it to be the case. We find, for example, that a regular succession of spinal nerves is given off from the spinal cord, one pair to each segment. From the brain arise from 10 to 12 pairs of cranial nerves, the number of which, however, does not tell us how many segments are fused to form the head. The number would be a guide if cranial nerves were precisely equivalent to spinal nerves, but this does not appear to be the case. While on the one hand some of them are complex, and equivalent to more than one pair of spinal nerves, others are only comparable to bits of such nerves, so to speak. The sympathetic system is closely

connected with the brain and spinal cord, to which it is subordinate, and its nerves branch out in the organs of digestion, circulation, &c. A few further details have already been given with regard to the nervous system of Man (see vol. i, p. 49).

It was stated at the commencement of this section that the essential elements of the nervous system, *i.e.* the neurons, are derived from the ectoderm or outer cell-layer. Considering that brain and spinal cord are far removed from the surface, while the body is traversed in all directions by nerves, it seems very difficult to believe such a statement, but the study of development shows that there is no doubt at all about the matter.

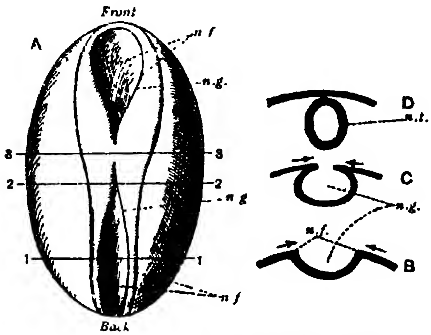


Fig. 1024.—Development of Central Nervous System in a Vertebrate Embryo, diagrammatic

A, Upper side of embryo, showing folding-up of the nerve-plate. B, C, and D, stages in folding up of nerve-plate, as seen in cross-sections through upper part of A, taken at levels 1–1, 2–2, and 3–3: *n g*, nerve-groove. *n f*, nerve-folds. *n.t.*, nerve-tube.

At a comparatively early stage in the development of an embryo part of the ectoderm covering the upper surface thickens into a nerve-plate, which sinks below the surface, and at the same time folds up to constitute the nerve-tube. The details for the Lancelet have already been given (vol. iii, p. 345), but in that animal the nerve-plate sinks below the surface before it is completely folded into a tube, while in average cases the two processes go on simultaneously, as will be gathered from fig. 1024.

The walls of the nerve-tube thicken, and by a process of unequal growth the spinal cord and the various regions of the brain come into existence. The rest of the nervous system grows out from the nerve-tube, *e.g.* the spinal nerves grow out from the spinal cord to the parts of the body which they supply. It therefore follows that these and the other nerves, as well as the sympathetic system, are really *ingrowths* from the ectoderm or outer cell-layer, although in the adult they are far removed from the surface.

THE BRAIN OF VERTEBRATES.—At first sight the brains of Fishes,

Amphibians, Reptiles, Birds, and Mammals look so extremely unlike that comparison seems hopeless, but such an idea is soon dispelled by a study of development, which is the key to the whole matter. What takes place is broadly as follows (fig. 1025). The front end of the nerve-tube grows rapidly, and divides into three successive swellings, which we may term the Fore-, Mid-, and Hind-Brains. These three original swellings are converted into the central part or axis of the adult brain, the front part of which is called the 'Twixt-Brain, and the hind part the Medulla Oblongata or Spinal Bulb (continuous behind with the Spinal Cord), while the roof of the middle section is thickened into a pair of swellings known as Optic Lobes, each of which, in Mammals only, is divided into two smaller projections by a

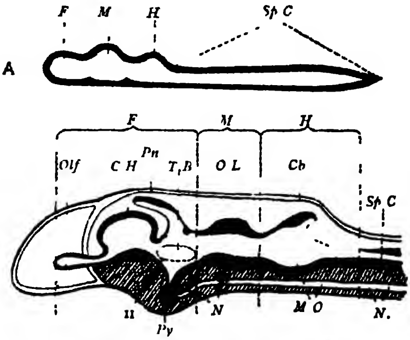


Fig. 1025.—Development of Vertebrate Brain, as seen in Longitudinal section diagrammatic

A, Brain and spinal cord at early stage; B, brain at later stage enclosed in brain case the floor of which is shaded with oblique lines. F, M, H, Sp C, fore-, mid-, and hind-brains, and spinal cord; T B, twixt brain; C H, cerebral hemispheres; Olf, olfactory lobe projecting into nasal capsule; Pn and Py, pineal and pituitary bodies; O L, optic lobes; M O, medulla oblongata; Cb, cerebellum; N N, notochord; II, optic nerve.

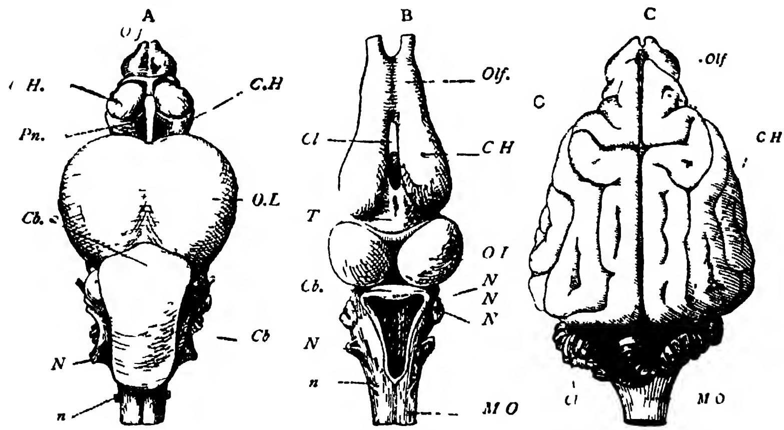


Fig. 1026. Brains of Trout (A), Frog (B), and Dog (C), seen from above, and drawn same length.

Olf, Olfactory lobes; C H, cerebral hemispheres (Cl is a cleft between them in B); T, twixt brain; Pn, pineal body; O L, optic lobes; Cb, cerebellum; M O, medulla oblongata; N, N, N, cranial nerves; n, n, spinal nerves.

transverse groove. The differences between various classes of Vertebrates mainly depend upon the relative size and structure of certain outgrowths from the axis, the position of which will be realized by reference to fig. 1026. From the 'twixt-brain two lobes grow out, which become the Cerebral Hemispheres (represented in some Fishes by a single lobe), from the front end of which spring Olfactory Lobes, related to the organs of smell. An unpaired outgrowth, the Cerebellum, arises from the upper side of the hind-brain. In Birds and Mammals the Cerebral Hemispheres and Cerebellum are of such great relative size that they largely overlap and conceal the central axis. That the brain should be made up of so many parts is a result of the division of physiological labour, these different parts sharing between them the work that has to be done. The most responsible duties are vested in the Cerebral Hemispheres, to which all the other regions are subordinate. The other regions of the brain, the spinal cord, and the sympathetic system, all have important shares in the work of the nervous system, but all are subsidiary to the cerebral hemispheres, which exercise supreme control over the body at large, and are the chief centres of correlation and adjustment. And besides this, consciousness, sensation, will, and intelligence are dependent upon them. As we ascend the scale among the Vertebrates we shall find the hemispheres getting relatively larger and more complex, as the expression of a centralizing tendency (fig. 1026). There is also a great deal of division of labour between the parts of the hemispheres themselves, and their highest duties appear to be discharged by what is known as the cerebral *cortex*, an external layer of nerve-cells. In all the higher Mammals the extent of this cortex is more or less increased by the presence of winding furrows, resulting from a process

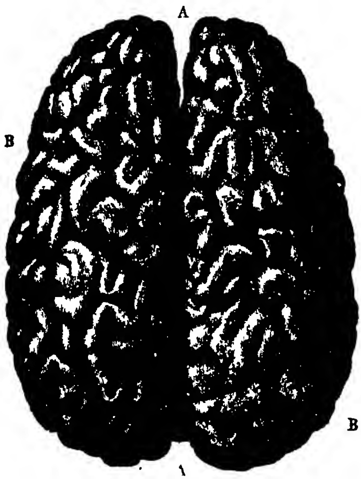


Fig. 1027.—Cerebral Hemispheres of Man, seen from above. A A, Cleft between hemispheres; B B, convolutions.

of folding or convolution. These attain their maximum complication in the human subject, where also the hemispheres are of relatively enormous size (fig. 1027). The amount of convolution is related to the intelligence of the particular species, but hasty deductions must be avoided, since they are also proportionate to the bulk of the body. Some of the most brilliant advances in modern surgery are due to the discovery that the cerebral cortex is divided into nerve-centres, some of which are concerned with sight, hearing, and other special sensations, while others again control definite sections of the muscular system. But so far it has not been found possible to locate the higher mental functions, such, for example, as memory. The Cerebellum also possesses a very complicated cortex. As might be expected, the minute structure of the brain in a higher Mammal is most remarkably complex. Details would be out of place here, but fig. 1028, which represents one of the most specialized neurons from the cortex, will suggest the elaboration which exists, bearing in mind that the number of neurons in the brain is enormous. And it is particularly interesting to know that, as recent investigations have proved, these ultimate elements of the nervous system maintain themselves during the entire life of the animal. There are not successive crops of nerve-cells as once supposed. Were this the case, indeed, such things as memory would be almost unintelligible.

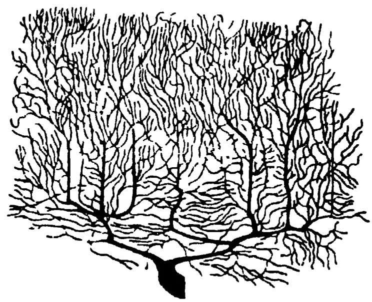


Fig. 1028. Complex Neuron from Cortex of Human Brain, greatly enlarged

CHAPTER LVIII

SENSE-ORGANS OF INVERTEBRATES AND VERTEBRATES

Sense-organs are the intermediaries between the nervous system and the environment, and essentially consist of ectoderm cells (end-organs) capable of being influenced by external agents or stimuli. The stimulation of a sense-organ may be immediately followed by a reflex action, or it may lead to a voluntary action, and it is commonly associated, in higher animals at least, with what is technically termed a *sensation*, *i.e.* an awareness of something in the surroundings. Supposing that in ourselves a light is suddenly flashed in the eyes when it is night. The eye is first affected, then the optic nerve, and then some of the nerve-cells in the brain. It is not till these last are brought into operation that we "see a light", and by comparison with past experiences are put into possession of a piece of information about our surroundings. It must be added, that besides special sensations, such as those of hearing, sight, &c., there are others of obscurer nature, which tell us something about the state of the body itself, and are known as *organic sensations.* Such are feelings of hunger, discomfort, &c., which, though of great importance for the well-being of the body, since they often guide to actions, *e.g.* feeding, which conduce to its welfare, will not be considered here, since they are not related to special sense-organs. Nor will reference be made to the "muscular sense", by which muscular efforts are gauged.

It will be convenient to place the subject-matter of the present chapter under the time-honoured headings of Touch, Taste, Smell, Hearing, and Sight, for it is by means of sensations which can be broadly classified in this way that we derive most of our knowledge of surroundings. But many of the lower animals possess sense-organs of which we can only conjecture the use, and the stimulation of which must result in

sensations of which we can form little if any idea. And even when with reasonable certainty we can correlate sense-organs possessed by such animals with some of our own, it by no means follows that the *range* of a given sensation is the same for one of them as for ourselves. As regards hearing, for example, there is reason to think that some animals can hear sounds which are pitched much higher than any by which we are affected; nor is this very surprising when we reflect that the range of hearing is not the same in all human beings. Many persons, for example, cannot hear the high and piercing sounds made by Bats. These remarks are made as a warning against applying the results of human physiology to lower animals with too great assurance.

TOUCH

Undoubtedly the most primitive of all the senses is that of Touch, and we may broadly state that the skin is the Tactile Organ, remembering that its outer layer, commonly known as the epidermis, is no other than the ectoderm or outer cell-layer of the embryo. We must also include here the cellular lining of the mouth-cavity and, when such exist, the nasal cavities,

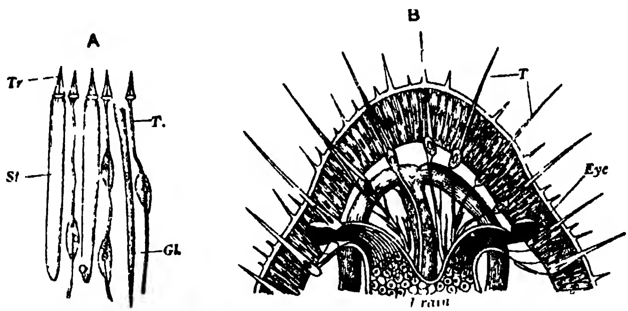


Fig 1020 Tactile Organs A, Cells from the ectoderm of a Sea Anemone (*Actinia*) *T* a touch cell, with outer end produced into a stiff process *St*, stinging cell with sensitive trigger hair (*Tr*) *Gl*, glandular cell B, Head of a Freshwater Annelid (*Lohemilla comata*) seen from above, and showing epidermis in optical section, enlarged *T* tactile processes of some of the epidermic cells, which are continuous internally with nerve fibre

since these have been developed as in-pushings of the ectoderm. The external agents of stimuli which by their action upon the skin evoke sensations of touch are of two sorts. There are, in the first place, mechanical agents, such as contact or pressure, and, in the second place, heat-rays. The sensations which result are respectively known as *haptic* and *thermal*.

Single epidermal cells or groups of such cells are specialized for the reception of stimuli leading to sensations of touch, but in such forms as Cœlenterates and Annelids many scattered cells of the kind probably minister to other senses besides that of touch. And it must be remembered that even the special sense-cells of hearing and sight are derived from the skin, which is in fact the primitive sense-organ. Cells which are regarded as tactile, from some of the lowest animals, are represented in fig. 1029.

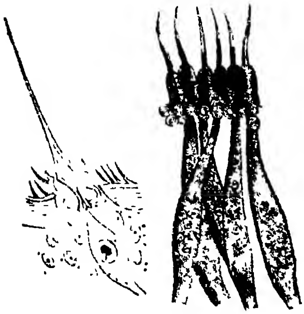


Fig. 1030.—Tactile Organs of Insects, greatly enlarged. On the right is a group of such structures, and on the left a single one, in section.

The firm external covering with which the bodies of Arthropods are clothed is naturally a hindrance to the reception of stimuli by the underlying epidermis. The difficulty is got over by the existence of little pores in the hard investment. Under each pore is an enlarged sense-cell, placed at the base of a stiff tactile bristle, with which external bodies come into contact (fig. 1030).

In aquatic Vertebrates the sense-cells of the skin are in direct contact with the surrounding medium, although they are not infrequently protected by being lodged in pits, grooves, or canals which open at intervals to the exterior. But in terrestrial Vertebrates there are special end-organs of touch which have sunk below the epidermis, though they remain sufficiently near to the surface to be stimulated when the body comes into contact with surrounding objects. Such are the groups of touch-corpuscles which are to be found in the skin of the Frog, and around the edge of the Duck's bill (fig. 1031). The latter animal feeds upon small worms, &c., which live in the mud that is strained through its bill, and such special arrangements are clearly necessary to aid in the discrimination between what is edible and what is not. Another example is afforded by the

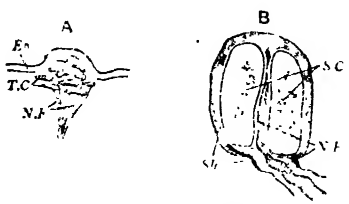


Fig. 1031.—Organs of Touch.

A, Small piece of the skin of a Frog, in vertical section, enlarged. *Ep.*, epidermis; *T.C.*, touch corpuscles; *N.F.*, nerve-fibres. B, Touch-corpuscle from the bill of a Duck, much enlarged. *S.C.*, sense-cells; *N.F.*, nerve-fibre; *Sh.*, fibrous sheath.

numerous touch corpuscles which underlie the little ridges seen on the tips of our fingers and thumbs (fig 1032) In Reptiles, Birds, and Mammals there are also curious structures known as Pacinian bodies (fig 1033), in which the ending of a nerve is surrounded by a series of layers arranged almost like the coats of an onion There is reason to think that these are very sensitive to slight pressures They abound, for instance, in the wing membranes of Bats, and it is well known that these creatures can easily steer their way in the dark through a veritable maze of obstacles, such as that afforded by a series of strings running in various directions Pacinian bodies are also found connected with tendons, ligaments and various internal organs. The use of these is probably to apprise the central nervous system of variation in pressure and tension which take place as between the different parts of the body itself

Fig 1032 —Touch Corpuscle from Finger Tip (Much enlarged)

We are still very much in the dark as to how far there do or do not exist special end organs which are affected by variations in temperature It is known that definite spots in the human skin are sensitive to such variations, but there do not appear to be any special sense organs in these spots Some of the sensory nerve-fibres terminate in the skin by dividing into a number of little branches which do not become continuous with modified epidermal cells, and it has been suggested that these "free nerve endings" are related to the temperature sense

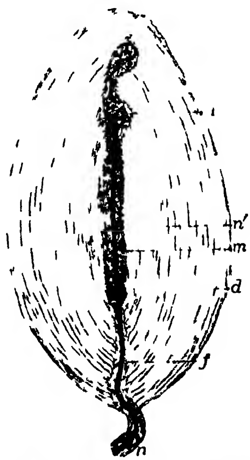


Fig 1033 A Pacinian Corpuscle in Longitudinal Section enlarged A nerve fibre (n n) surrounded by a sheath f, enters the base of the corpuscle, loses its sheath, traverses a central core m, and ends in an irregular expansion d) The corpuscle is mostly made up of numerous concentric fibrous layers c, d)

While the entire external surface of the body is sensitive to contact, pressure, and changes in temperature, this is in many cases insufficient to enable the requisite adjustments to the environment to be brought about And we accordingly find that in many animals organs of active touch have been evolved, which explore the

surroundings, and help to detect the presence of food, or to give warning of danger. Such are the tentacles of Jelly-Fish and Sea-Anemones, the slender outgrowths on the head of a Sea-Centipede, the two pairs of antennæ on the head of a Cray-fish, the single pair on the head of an Insect, and the tentacles on the heads of Snails and Slugs. The "whiskers" of a Cat or Rabbit belong to the same class of structures. They are stiff

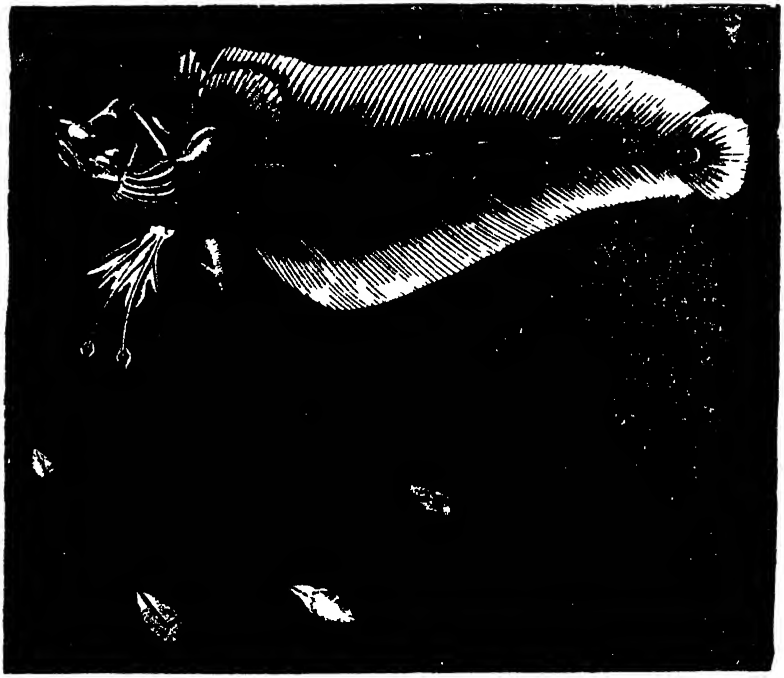


Fig 1034 —A Deep-Sea Fish *Eretmophorus*) with its Pelvic Fins drawn out into long Tactile Organs

hairs, at the base of each of which a touch-corpuscle is to be found. Such organs of active touch may either from the first have done duty as sensory organs, or may have originally been evolved in the interests of some other function. The former is probably true for the feelers of a Sea-Centipede or Insect, but the large feelers of a Crayfish (and very likely the small ones too) were probably jaws at an earlier stage, having later on been shifted in front of the mouth, and modified in shape and structure to do duty as sense-organs. There can be no doubt that the paired fins of Fishes were originally evolved in

relation to swimming, but it sometimes happens that they have been transformed into tactile organs, as in the deep-sea form (*Eretmophorus*) represented in fig. 1034. Snakes employ their tongues as tactile organs, as also do Woodpeckers and Ant-eaters. This, however, is probably only an extension of the original duties, for the primary use of the tongue seems to be that of a tactile organ in relation to the mouth-cavity.

TASTE

Sensations of Taste are primarily important because they assist in the selection of suitable food. The stimulus is a chemical one, and consists of substances in solution. We know but little about the gustatory organs of lower forms, but as these show a preference for certain kinds of food it is probably correct to assume that such organs are present. In the Earth-Worm, for example, groups of modified epidermal cells in the neighbourhood of the mouth are very likely related to taste.

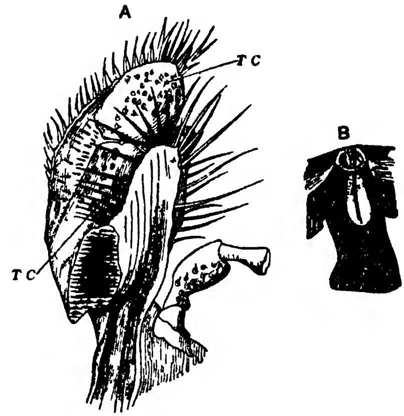


Fig. 1035. Taste Organs of a Wasp. A, Under side of left maxilla enlarged showing group of taste-cups (*T C*). B, A single taste cup, greatly enlarged.

Certain regions of the mouth-parts of some Insects are studded with minute pits, beneath each of which is a sense-cell, drawn out externally into a short bristle, and continuous with a nerve-fibre internally. They are present, for example, in Bees and Wasps, and are almost certainly of a gustatory nature (fig. 1035).

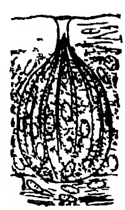


Fig. 1036.—Taste Bud from the Tongue of a Rabbit, in longitudinal section, greatly enlarged. The bud contains slender taste cells, the external ends of which project into a little pit continuous with the mouth cavity.

Cuttle-Fishes and many Snails possess a sense-organ on the floor of the pharynx, below the front end of the rasping-ribbon. It probably has to do with taste.

In Lung-Fishes, Amphibians, Reptiles, Birds, and Mammals the organs of taste consist of groups of sense-cells in the lining of the mouth-cavity, and since this cavity is developed as an

in-pushing from the exterior the cells in question are of ectodermic nature. The largest amount of specialization takes place in Mammals, where the "taste-buds", as the group of cells are called, are associated with small projections or papillæ of the surface of the tongue (fig. 1036).

SMELL

Many of the lower animals can undoubtedly smell as well as taste, though to definitely associate this sense with special cells or groups of cells is not at present possible. Our knowledge is more complete in the case of Arthropods, Molluscs, and Vertebrates, where experiments lead to results of more de-

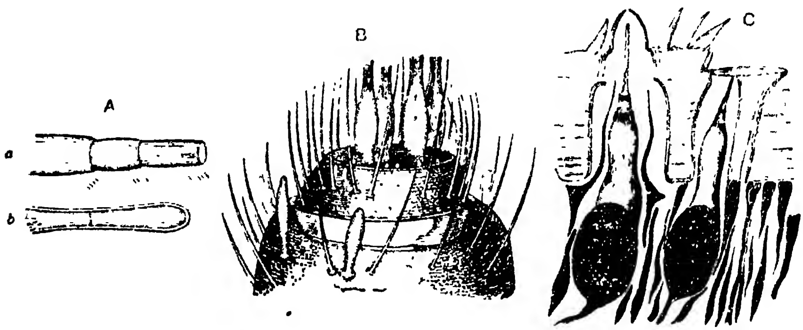


Fig. 1037.—Olfactory Organs. A, A small part of the outer branch of antennule of a Crayfish is shown at *a*, with groups of olfactory setæ on its under side, enlarged; *b*, an olfactory seta, further enlarged. B, Tip of feeler of a Millipede, greatly enlarged, showing olfactory cylinders among the ordinary tactile bristles. C, Two olfactory cones from feeler of a Wasp, in section, greatly enlarged.

finite kind. In all cases the stimulus is of a gaseous nature, and in aquatic animals the gases that are smelt are dissolved in the surrounding water. The sense of smell is obviously of great importance as regards adjustment to the environment. By its means food is in many cases detected, while it often enables animals to recognize friends or foes, even when these are at a considerable distance. This is, of course, due to the nature of the stimulus. Since Smell, Hearing, Sight, and the Temperature Sense are able to give information about objects which are more or less far away, they may be grouped together as Distance-Senses (telæsthetic senses), and are in marked contrast to Touch (so far as haptic sensations are concerned), which only conveys knowledge regarding things that actually come into contact with the skin.

There is naturally a tendency for olfactory organs to be developed at the front end of the body where they can be most usefully employed, and they are commonly to be found on the feelers of Arthropods. In the Crayfish, for example, the small first feelers (antennules) bear groups of flattened bristles which undoubtedly have to do with smell, and similar structures are present on the antennæ of Millipedes and Insects (fig. 1037).

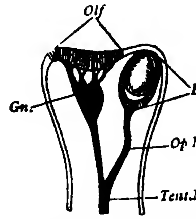


Fig 1038.—Tip of Optic Tentacle of Garden Snail in diagrammatic longitudinal section, enlarged The tentacular nerve (*Tent N*) gives off an optic nerve (*Op N*) to the eye, and then expands into a ganglion (*Gn*) which sends fibres to an olfactory patch (*Olf*) of cells on the tip of the tentacle

Land-Snails and Slugs, among the Molluscs, are known to be endowed with a keen sense of smell. In the common Garden-Snail (*Helix aspersa*) some of the epidermic cells at the tips of the long eye-bearing tentacles are believed to minister to this function (fig. 1038), though experiments have been made which appear to show that olfactory cells are elsewhere present

Among aquatic Molluscs what is known as a water-testing organ (osphradium) is usually present in the neighbourhood of the breathing organs (fig. 1039). This is generally considered to be of olfactory nature.

In Vertebrates the sense-cells related to smell form part of the lining of the cavities of the nose, and since these are developed as pits in the external surface, such cells must necessarily be of ectodermic character. When the sense of

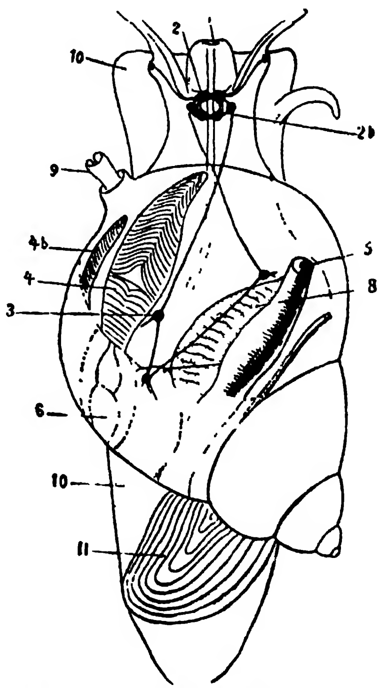


Fig 1039.—Diagram of a Comb-gilled Snail, seen from above The roof of mantle-cavity and overlying shell supposed transparent

1, Mouth 2, brain ganglion 2b, nerve cord connecting side ganglion (above) with foot ganglion below) 3, one of the three ganglia on the twisted nerve loop 4, gill, 4b, osphradium 5, opening of intestine, 6, heart in pericardium; 8, a gland (purple gland in Purpura) 9, siphon 10, 10, foot: 11, operculum

smell is keen the nasal cavities are large and complex, and folds project into them which increase the surface over which olfactory cells are distributed. These cells are frequently of the shape represented in fig. 1040, from which it will be seen that from the outer end a number of slender processes project into the nasal cavity. In some Fishes, such as the ordinary bony forms, the originally single nostril of each half of the nose is divided into two apertures, which respectively serve for the entry and exit of water, that appears to flow continuously through the nasal cavity. There can be no doubt that many fishes possess a very keen sense of smell, and the experiments of Bateson have proved that some of them (*e.g.* Dog-Fish, Conger-Eel, and Sole) are mainly guided by this in their search for food. This being so, the nocturnal habits of many species is readily intelligible, and the sense of smell must also be very useful in water of such depth that the light is dim.

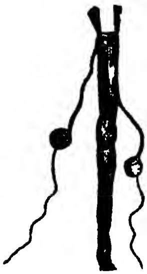


Fig. 1040.—Two Olfactory Cells from an Amphibian (*Proteus*), greatly enlarged

In Vertebrates which live on land the courses taken by the food which is swallowed and the air that is breathed are more or less distinct. Each nasal cavity, in fact, opens at the back into the digestive tube, and the natural way of breathing is "through the nose". This is clearly to the advantage of the sense of smell, for the air which passes over the olfactory cells is constantly being renewed, and the incoming current is continually bringing with it gaseous matter capable of being smelt. An inward flow is greatly promoted by the act of "sniffing", as we know from our own experience.

BALANCE AND HEARING

There are certain sensory structures among the Invertebrates which though often classified as Auditory Organs have probably nothing to do with hearing in the ordinary sense, but are concerned with advantageous adjustment of the body as regards its position in space. This is of the greatest importance in reference to the maintenance of balance and the direction of movement. They are stimulated by vibrations in the surrounding medium, water or air as the case may be, and there can be little doubt that they have furnished the material from which undoubted

organs of hearing have been evolved. Indeed the auditory organs still retain, in ourselves for instance, the old function side by side with the new.

Balancing Organs of Jelly-Fish (Hydrozoa).—Jelly-Fish are often provided with balancing organs placed at regular intervals round the edge of the umbrella. In the simplest case these are little pits lined by specialized sense-cells, from each of which a bristle projects. Within the pit one or more calcareous particles (otoliths) are found, and these also have been derived from the ectoderm. In many species the mouths of these pits close up, converting them into little sacs (otocysts) which lie close to the surface. Other kinds, again, possess short balancing-tentacles (tentaculocysts), evolved no doubt from some of the ordinary sort (fig. 1041). In such instances the otoliths are derived from the entoderm cells which make up the inner part of the tentacle. Though these different organs may be constructed in various ways they are affected by the same sort of stimulus. Their sensory cells are jolted by movements in the surrounding water and by the swimming movements of the animals themselves, and the otoliths appear to intensify the action, as it were. The sense-cells are closely connected with the nervous system, and this again with muscle-fibres. We have present, in fact, the necessary machinery for muscular reflex actions (see p. 9), under which may be included the checking or stopping of swimming movements actually in progress.

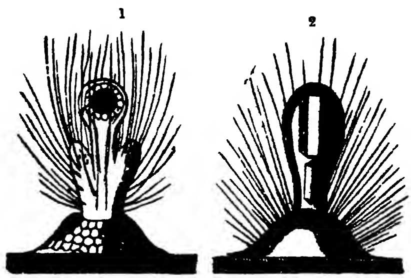


Fig 1041 – Tentaculocysts of Jelly Fish, enlarged
1, Of *Solmaris coronantha*. 2, of *Polyxenia cyanostylis*

One of the most obvious uses of the sense-organs described appears to be that of enabling their possessors to keep well below the surface of the water during rough weather, for creatures of such flabby and delicate structure are quite unfitted to withstand the buffets of the waves. Supposing that on a stormy day a jelly-fish is swimming obliquely upwards. When it comes sufficiently near the surface for the balancing organs to be stimulated with a certain degree of vigour by the swing

of the water, reflex modification of the swimming movements will take place, and the upward course will be altered into a downward one.

BALANCING ORGANS IN SEGMENTED WORMS (ANNELIDA).—Members of this group commonly react very quickly to jolting or agitation of the surrounding medium, and this may lead to movements promoting escape from danger. Earth-Worms, for example, when partly protruding from their burrows, will often draw back with extreme rapidity on the approach of a heavy footstep. The skin is no doubt the sense-organ in this case, but we are ignorant as to details. A few Annelids, however, have a pair of otocysts in the front part of the body, as, *e.g.*, the Common Lob-Worm (*Arenicola piscatorum*), where they are closely connected with the brain (fig. 1042). They have undoubtedly been evolved from pits in the ectoderm like the similar sacs found in some of the jelly-fish, and three stages in this evolution are permanently retained in three kinds of Lob-Worm. In one of these (*A. Claparedii*) there is simply a pair of depressions on the head, in another (*A. piscatorum*) otocysts which are still in communication with the exterior, and in a third (*A. Grubii*) closed otocysts. The otoliths of the second species are minute sand grains taken in from the exterior, while those of the third are calcareous particles secreted by the ectoderm.

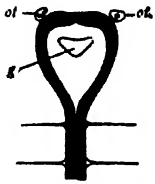


Fig. 1042 — Front Part of Central Nervous System of Lob-Worm (*Arenicola piscatorum*), enlarged *g*, Gullet (in cross section traversing nerve ring. *o*., otocysts in close connection with the brain (canals to exterior not shown)

BALANCING ORGANS IN MOLLUSCS (MOLLUSCA).—Most Molluscs possess a pair of otocysts, developed as pits in the ectoderm, which become closed and travel inwards to the neighbourhood of the foot. They are attached to the foot-ganglia, although their nerve-supply is derived from the brain (see fig. 1021, p. 17). It occasionally happens in Bivalves that the communication with the exterior is retained. The lining of these organs partly consists of sense-cells provided with stiff processes, and one or more calcareous otoliths are present.

The otocysts of Cuttle-Fishes and their allies are lodged in the gristly case which surrounds the thickened nerve-ring, pretty much as in backboned animals the corresponding organs are sheltered in gristly or bony capsules that form part of the wall

of the brain-case. And it is definitely known that in Molluscs of this kind maintenance of equilibrium and adjustment of the swimming movements are seriously interfered with if the otocysts are injured, which leaves little doubt as to the use of these organs.

The otocysts of some of the free-swimming Sea-Snails (Heteropods) are particularly large and well-developed (fig. 1043), and are undoubtedly related to balance and steering. The majority of Snails and Slugs, however, are adapted to a creeping mode of life, the organ of locomotion being the muscular flat-soled foot, which is also concerned with maintaining the balance of the body. Since the otocysts are presumably related to both these uses, it is not surprising to find them placed close to the upper surface of the foot, by the slightest movement of which they must therefore be affected, and H. J. Fleure has described an interesting arrangement in the Limpet and Sea-Ear which probably conduces to this. In the two forms mentioned each otocyst is connected with the foot by a fibrous band, and there is a similar bond between the two otocysts (fig. 1044). These organs are thus kept "in touch" with the foot and with one another, and, being also moored by their nerves to the foot ganglia, are kept steady, which seems desirable when their functions are considered.

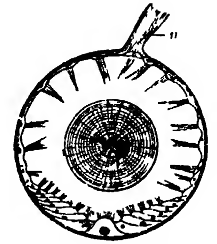


Fig. 1043.—Otocyst of a Heteropod (*Pterotrachea*) in section, enlarged. The large otolith is seen in the centre of the vesicle, which is lined below by sensory cells provided with bunches of short stiff projections; the rest of the vesicle is lined by cells bearing long cilia. *n*, nerve.

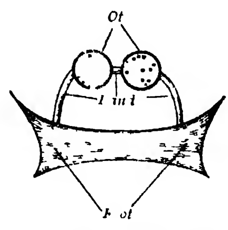


Fig. 1044.—Diagrammatic Cross Section through Otocysts (*Ot*) and Foot of a Limpet, enlarged.

Organs of Balance and Hearing in Crustaceans (Crustacea).—Such higher forms as Lobsters, Prawns, Shrimps, and Crabs are provided with otocysts lodged in the bases of the small feelers or antennules. These organs arise, as in cases already described, as pits in the ectoderm, and they usually, though not always, remain open through life. In a Lobster, for example, they are lined by a thin horny membrane continuous with the hard covering of the body, and studded with delicate bristles, at the bases of which are sense-cells (fig. 1045). The otoliths are sand grains which have been taken in from the exterior

That the otocysts are concerned with equilibrium and adjustment of movement has been definitely proved by experiments upon the Prawn (*Palæmon*). When this creature moults it sheds not only the defensive armour of the body but also the lining of the otocysts, getting rid at the same time of the sand grains which serve as otoliths. Under ordinary circumstances these would be replaced by a fresh supply of the same material, but the specimens experimented upon were only provided with iron filings, some of which in due course were introduced into the otocysts. It was then found possible by means of a magnet to move the particles in various ways, and as a result of this the Prawns could be induced to assume all sorts of positions, under the impression, so to speak, that they were falling over in this or that direction, which they would have been if the shifting of the otoliths had been produced by ordinary causes.

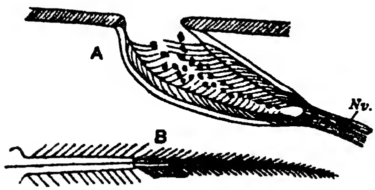


FIG. 1045.—Otocyst of Lobster (A) in longitudinal section, enlarged and diagrammatic; sensory bristles are seen projecting into its cavity, which contains numerous otoliths; *Nv*, nerve. B, A sensory bristle, further enlarged

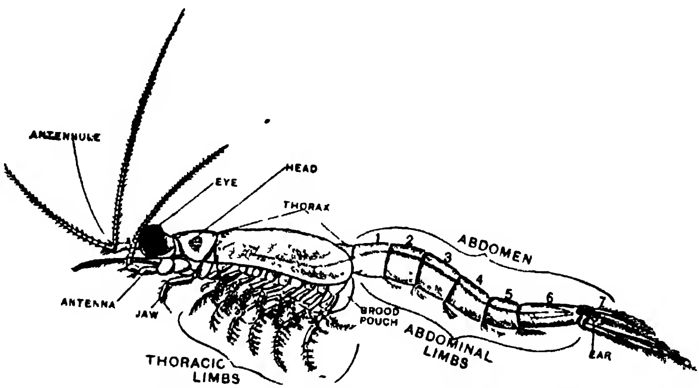


FIG. 1046.—Opossum Shrimp (*Mysis*), enlarged. One of the otocysts (EAR) is seen in the tail

In one Crustacean, the Opossum Shrimp (*Mysis*), the otocysts, in this case closed, are lodged in the flaps of the tail-fin, but why they should have this position is not known (fig. 1046).

It is generally assumed that animals which are endowed with a voice or its equivalent also possess powers of hearing, at least if the voice is used for the benefit of one another. Since some

of the higher Crustaceans are able to emit sounds, it is quite possible that their otocysts are beginning to acquire a new use, *i.e.* that of serving as auditory organs. The Rock-Lobster (*Palinurus*), for example, makes a creaking noise by moving the basal joints of the large feelers, which then rub against their sockets. An unpleasant sound of similar nature can be produced by twisting a glass stopper in the neck of its bottle. A more specialized case is that of the Musical Strand-Crab (*Ocypoda macrocera*), which has been described by Alcock (in *A Naturalist in Indian Seas*). In this animal the inner side of the large nippers is provided with a ridge or scraper placed near the base of the limb, and a rasp-like ridge or key-board on the fixed joint of the claw. By drawing the scraper over the key-board a sort of chirping sound is produced, not unlike the one with which our native grasshoppers have made us familiar. The same zoologist speaks of the Squeaker Crab (*Psopheticus stridulans*) of the Andaman Sea as making a dismal noise by rubbing a spine which projects from the base of its nippers against a rough knob near the eye-socket.

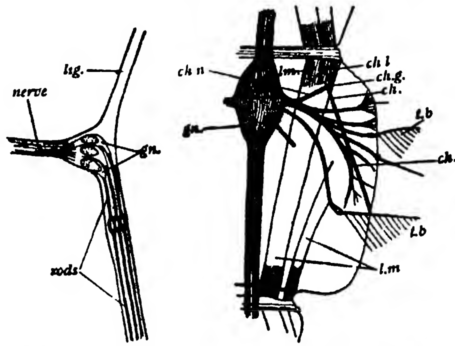


Fig 1047—Chordotonal Organs On the right is shown part of an abdominal segment of the larva of a Gnat (*Corethra plumicornis*), seen as a transparent object, enlarged. In the centre is the nerve cord (darkly shaded) with the ganglion (*gn.*) of the segment; *l m*, longitudinal muscles; *ch n*, *ch g*, *ch.l.*, and *ch.*, chordotonal nerve, ganglion, ligament, and organ; *t b.*, branched tactile bristles. On the left is seen part of the chordotonal organ with its rods, ganglion (*gn*), nerve, and ligament (*lig*) still further enlarged.

Organs of Balance and Hearing in Insects (Insecta).—A variety of organs situated in different parts of the body are probably connected with balance or hearing, or both. Among those which are most likely concerned with equilibrium and movement are certain peculiar structures (chordotonal organs) that are especially characteristic of aquatic larvæ, though not limited to these. Gnat larvæ, for example, possess such organs, one of which is represented in fig. 1047. It consists essentially of a group of rod-shaped cells contained in a tube that opens to the exterior.

Many insects make sounds which are doubtless heard by

their fellows, a well-known instance being afforded by Grasshoppers and Crickets. A Grasshopper possesses a chirping arrangement something like that of the Musical Strand-Crab (p. 37). The wing-cover is provided with a sharp edge or scraper which is rubbed along a key-board placed on the inner edge of the thigh of the hind-leg (fig. 1048). The chirping sounds audible to our own ears are produced by the male insect, but the females of some species are also provided with these "stridulating" organs, which no doubt make sounds that can be heard and appreciated by the opposite sex. These sound-producing insects also possess what we may feel justified in calling "ears". On either side of the first ring of the abdomen there is a membrane comparable to a drum-head (fig. 1048) stretched over an air-space, and closely connected with sensory arrangements somewhat like those already described for a gnat-larva.

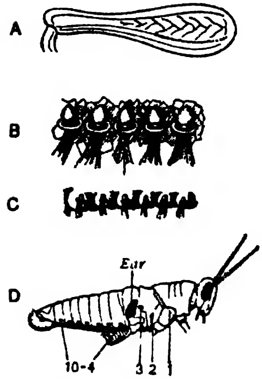


Fig. 1048.—Stridulating Organs and Ears of Grasshoppers. A, Hind thigh of a male Grasshopper (*Stenobothrus*), showing beaded key-board (dotted line on right), enlarged. B, five beads of same, further enlarged. C, six of the much smaller beads of key-board of a female (same scale as B). D, side view of a Grasshopper (*Acridium*) to show ear; wings and legs cut short; 1–3, thoracic stigmata; 4–10, abdominal stigmata.

The ears of Green Grasshoppers and Crickets are situated in the shins of the fore-legs, just below the knee.

Organs of Balance and Hearing in Backboned Animals (Vertebrata).—The tadpole larvæ of Sea-Squirts possess remarkable sense-organs formed by specialization of part of the wall of the brain, and projecting into its cavity. One of these is of the nature of an otocyst, and is probably a balancing organ (fig. 1049).

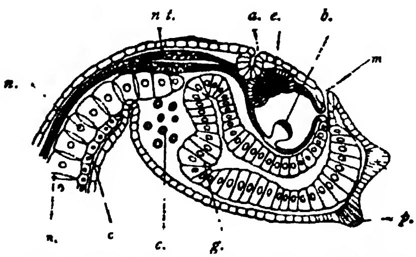


Fig. 1049.—Body of an Ascidian Tadpole, in longitudinal section, enlarged. The tail is cut short. the dorsal nerve tube (*n t.*) swells into a brain, into which project a balancing organ (*b.*) and an eye (*e.*), *a.*, atrial cavity, *c.*, groups of embryonic cells, *g.*, gut, *m.*, mouth, *n.*, notochord, *p.*, adhesive papillæ.

From Fishes onwards we find undoubted ears, similar, broadly speaking, to the essential parts of our own organs of hearing, and there can be no doubt that these also have to do with equilibrium and movement. If we trace the development of the

ear we shall find that it begins as a pit in the skin, and by closure of the mouth of this a vesicle is produced, which if it underwent no further modification would be called an otocyst. As it is, however, a very complex shape is assumed, the final result being known as the membranous labyrinth, or internal ear (fig. 1050). This sometimes, as in a Skate or Dog-Fish, remains in communication with the exterior throughout life. It is significant that in Fishes the auditory pit arises in close connection with the "lateral line", which is a groove or tube containing groups of sense-cells belonging to the skin. And this suggests that the ear is no more than a bit of this line which has sunk beneath the surface and become specialized as regards structure and function. It is extremely probable that the lateral line of Fishes and Amphibian larvæ has to do with maintenance of balance and direction of movements, and if so, the fact that the ear has to do with these functions is quite intelligible. We know so little about the division of physiological labour between the different parts of the complex labyrinth that a discussion of details would be out of place here. But experiments have shown that the semicircular canals have some connection with movement and equilibrium, and it is interesting to note that they lie in three planes which are mutually at right angles. It is also certain that the labyrinth is the sense-organ of hearing proper. In land-vertebrates there are more or less perfect arrangements for conducting air-waves from the exterior to the deeply-seated and well-protected internal ear. This has already been sufficiently illustrated by the brief account of the auditory organs of Man given elsewhere (see vol. i, p. 56).

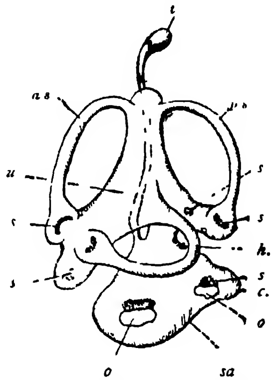


Fig. 1050.—Diagram of the Left Membranous Labyrinth of a Lower Vertebrate, seen from the outer side. *t*, A tube representing the outer part of the original ingrowth; *a s*, *p s*, and *h*, anterior vertical, posterior vertical, and horizontal semicircular canals; *u*, utricle; *sa*, saccule; *c*, cochlea; *o*, *o*, otoliths; *s*, *s*, *s*, *s*, *s* (and other dotted patches), groups of sense cells.

SIGHT

Skin-Seeing.—The simplest kind of sight is literally that of "seeing without eyes", and it amounts to no more than the power of distinguishing between light and darkness, or detecting

sudden variations in the amount of illumination. But even this limited sort of vision may be of the greatest importance to its possessor, since it often gives valuable information about the surroundings. In such skin-seeing (*dermatoptic vision*) it is usual to find colouring-matter or pigment in or below the epidermis, which localizes the action of light-rays upon sensitive cells in this layer. This is the case, for instance, in Earth-Worms, the safety of which must often depend upon their avoidance of light. A further and more interesting illustration is afforded by many of the bivalve Molluscs which live in sand or mud, and which feed and breathe by means of two tubes, the siphons, which project from the hinder end of the body (vol. ii, p. 249). Such animals are often found hidden in their burrows with only the extreme tips of the siphons projecting. But even though thus concealed they would more frequently fall victims than they do to octopi and fishes, or, in the case of those which live between tide-marks, to strand-haunting birds, were they not provided with some means of detecting the proximity of such enemies. Warning is often given by the siphons themselves, which are commonly pigmented and sensitive to changes in light-intensity. And experiments on specimens kept in aquaria have shown that the fully-extended siphons are rapidly drawn in if a shadow is suddenly cast upon them, an event that would happen under natural conditions on the approach of a voracious fish or too inquisitive bird.

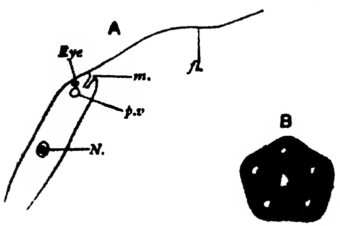


Fig. 1051.—A, *Euglena viridis*, enlarged. *fl.*, flagellum; *m.*, mouth. *N.*, nucleus. *p.v.*, pulsating vacuole. B, Eye-spot, greatly enlarged, showing six rounded lenses resting on a mass of pigment.

EYES.—Localization and improvement of the powers of sight have led to the evolution of definite visual organs or eyes, though many of the lower Invertebrates have more or less retained the old faculty of diffuse skin-seeing. The simplest organs of the kind are known as *eye-spots*, and their presence is marked by dense pigment. These are possessed even by some Animalcules, *e.g.* by a little green creature (*Euglena viridis*) which often swarms in stagnant water (fig. 1051). The eye-spot in this case is marked by the presence of a tiny patch of red colouring-matter on which rest several little lenses that serve to concentrate the light.

In some of the Jelly-Fish the margin of the umbrella bears

a number of compound sense-organs (rhopalia) derived from tentacles, and having to do with balance and adjustment of movements, sight, and possibly smell. Their visual part consists of a group of pigmented ectoderm cells, upon which a lens may rest (fig. 1052).

Examination of a Common Star-Fish (*Uraster rubens*) will

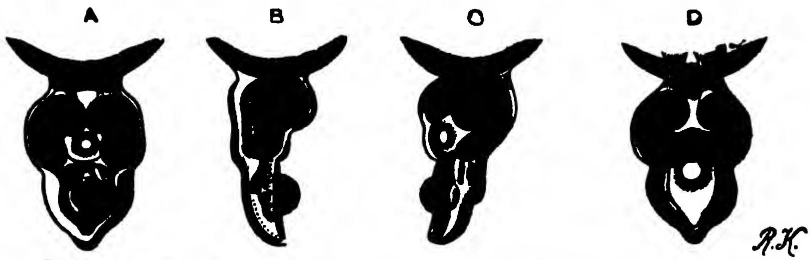


Fig. 1052.—Rhopalia of *Pericolpa quadrigata*, seen from various points of view, enlarged. The otocyst, containing numerous otoliths, is seen in the lower part of A, B, and C; the rounded pigmented eye, with clear, central refracting portion, is indicated in A, C, and D.

reveal the presence of a bright-red spot at the tip of each arm, borne upon an unpaired tube-foot. This is undoubtedly an eye, and microscopic examination shows that it is made up of a multitude of little cups, each of which is lined with elongated cells, some of which are sensory, while others contain pigment (fig. 1053). Sea Urchins possess a circlet of somewhat similar eyes placed near the upper pole of the body. In some of these animals each of the minute cups may be provided with refracting structures, which presumably concentrate the light.

Fig. 1053.—An Eye-Cup of a Star-Fish, greatly enlarged, in section. The retina is supplied with numerous nerve-fibres (*n.f.*).

Jelly-Fish, Star-Fish, and Sea-Urchins are radially symmetrical animals, and their eyes are correspondingly disposed. But in "Worms", Arthropods, Molluscs, and Vertebrates, where the body is bilaterally symmetrical, and there is a more or less well-developed head, the eyes are usually situated upon this, as being the most useful position. But eyes may be present elsewhere, especially in some of the Planarian Worms, and certain Bivalve Molluscs.

The visual organs so far described may be called Direction-Eyes, as they can do no more than detect the direction from which the light-rays which influence them are coming. Eyes of

the sort are present in many Worms and Molluscs, and some of them are less complex than those of a Jelly-Fish or Star-Fish. Nothing, for example, could be much simpler than the eye-spots on the head of the common freshwater worm Nais. Each of these is simply an enlarged epidermal cell, along one side of which are several much smaller cells containing pigment (fig. 1054). We may take as examples of greater complication the eyes of a Leech, a Limpet, and an Arrow-Worm, the nature of which is sufficiently indicated in fig. 1055. They essentially consist of a group of visual or retinal cells, associated with pigment and refracting structures. Those of the Leech are particularly interesting, because they closely resemble in structure certain organs of touch which are present in the skin of the same animal, differing from these, however, in being larger, surrounded with pigment, and limited to the front end of the body. It is, in fact, a case of tactile organs which are acquiring a new function. The simple

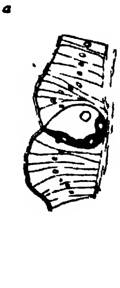


Fig 1054 – Section through an Eye Spot of a Freshwater Annelid (*Nais* with adjacent epidermic cells, enlarged *a o*, optic axis

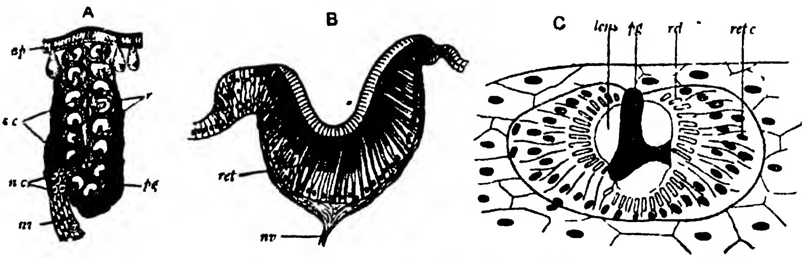


Fig 1055.– Direction Eyes of a Leech (*Hirudo*, A), a Limpet (*Patella*, B), and an Arrow-Worm (*Sagitta*, C), in section, and enlarged to various scales

In A the elongated eye is placed below a transparent patch of the epidermis (*ep*.) it is enclosed in a pigmented sheath (*pg*), and consists of an external layer of large refracting cells (*r c*), surrounding a core of slender sense cells (*s c*), which are continuous with nerve-cells (*n c*), and these again with nerve-fibres (*nv*) B is an open cup, lined by a thickened retina (*ret*) with clear refracting part externally, and dark pigment between its cells, *nv*, nerve. In C there are three lenses imbedded in pigment (*pg*), external to which are retinal cells (*ret c*), that contain refracting rodlets (*rd*) in their inner ends

eye-cups, of which one is to be found at the base of each tentacle in a Limpet, are interesting for quite a different reason. For they are almost certainly to be regarded as degenerate structures, which have been greatly simplified as a result of adaptation to the mode of life characteristic of their possessor. The activity of a Limpet is practically limited to feeding excursions in the vicinity

of its home, and the eyes are under the shadow of the large conical shell. Under such circumstances complex visual organs are unnecessary.

PICTURE-EYES.—The development of refracting structures in direction-eyes has led to the possibility of further specialization in vision, and has resulted in what we may call Picture Eyes, capable of giving more or less definite information about the form and colour of external objects. Two kinds of these may be distinguished, *i.e.* Compound Eyes and Camera Eyes.

Fig 1056.—Head of Male Honey-Bee (*Apis mellifica*) and Beginning of Thorax with First Pair of Legs, enlarged. The antennæ are seen in front, and three small simple eyes near their bases, but the most conspicuous structures are the enormous compound eyes, with their minute hexagonal facets

Compound Eyes are characteristic of a great many Arthropods, such as Lobsters and Crabs, where they are placed at the end of stalks, and Insects, where they are in the form of two large projections on the head (fig. 1056). Examination with a lens shows that such an eye is covered by a transparent patch of the hard covering of the body, which is divided into a multitude of minute square or polygonal areas, commonly known as facets. These may be exceedingly numerous, as will be seen from the following calculations made by Leeuwenhoek more than a century ago:—house-fly, 4000; gadfly, 7000; goat-moth, 11,000; death's-head moth, 12,000; swallow-tail butterfly, 17,000; dragon-fly, 20,000; a small beetle (Mordella), 25,000. It was originally believed that these elaborate structures were aggregates of simple eyes, acting independently; and they were therefore called "compound" eyes, a rather misleading term. Sections through such eyes (fig. 1057) have demonstrated that each facet is the outer end or base of a verv slender visual pyramid (ommatidium), the external part of which consists of various refracting structures, while internally is a group of sensitive visual cells connected with nerve-fibres. Adjacent pyramids are optically separated from one another by means of pigment. Comparison of various compound eyes shows that there are

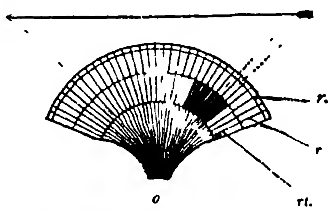


Fig 1057.—Diagram of a Compound Eye, in section, enlarged, to illustrate theory of "mosaic vision." Numerous radiating visual pyramids are indicated, each consisting of external refracting structures (*r.*, *r*) and internal groups of retinal cells (*rt.*) On the right side part of the pigment of several pyramids is inserted. The course of light rays from an external object is indicated for three pyramids. *o.*, optic nerve

great differences in detail, and much has yet to be learnt regarding the exact structure and use of the numerous parts which are present. The most plausible explanation which has yet been given of the mode of action of this sort of eye is that of "mosaic vision". According to this a visual pyramid is only stimulated by light-rays which exactly correspond in direction with its long axis, and numerous pyramids co-operate so as to enable the shape and colour of surrounding objects to be perceived (fig. 1057).

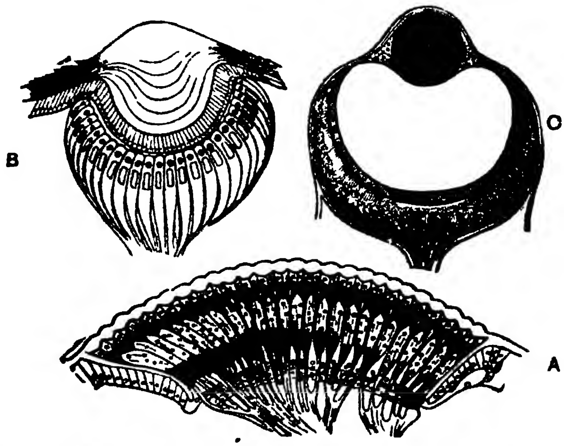


Fig. 1058.—Sections through the Compound Eye of an Earwig (*Forficula*, A), and the Camera Eyes of a Spider (*Epeira diadema*, B), and a Marine Annelid (*Alciope*, C), enlarged.

In A numerous radiating visual pyramids are seen, ending externally in the facets of the thickened cuticle, and connected internally with nerve branches; one of the pigmented zones is indicated. In B the cuticle is thickened into a rounded lens, and behind this is a transparent layer upon which abut the retinal cells, continuous with nerve fibres; each retinal cell contains a refracting rodlet. C is a vesicle, of which the external part is thickened into a spheroidal lens, while the rest constitutes a retina, consisting of an internal refracting layer, separated by pigment from the external sensitive part, into which nerve fibres are seen running.

Camera Eyes are found in Annelids, Arthropods, Molluscs, and Vertebrates. Just as in a photographer's camera a picture of external objects is imaged on a sensitive plate by means of a lens, so also in a camera eye do we find refracting structures which focus light-rays on a retina, or layer of sensitive visual cells. Scattering of light is prevented in the former case by a blackened lining, in the latter by a layer of pigment.

One of the two exceptionally large eyes present on the head of a marine Bristle-Worm (*Alciope*) is represented in fig. 1058. A Sea-Centipede (*Nereis*) possesses four smaller and less complex eyes of similar kind on the upper side of its head-lobe, and in some of the tube-inhabiting Bristle-Worms (*e.g. Branchiomma* and

Dasychone) there are eyes of elaborate nature on the gill-filaments of the head.

Spiders, among Arthropods, have a group of simple eyes (ocelli) on the top of the head. These are constructed on the camera principle, though they differ in detail from those of Alciope (fig. 1058). The spherical shape of the lens and its closeness to the retina suggest that only near objects can be seen with any degree of distinctness. A great many Insects possess ocelli in addition to the two large compound eyes. In Bees, for instance, there are three of these arranged in a triangle on the top of the head. In this and similar cases it is extremely probable that the compound

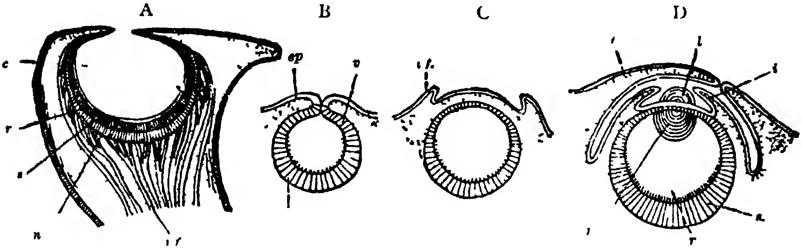


Fig. 1059.—Diagrammatic Sections through Camera Eyes of Cephalopods.

A, Eye of Nautilus: c, internal cavity; r and s, refracting and sensitive layers of retina; n.c, layer of nerve-cells; n.f, nerve fibres. B–D, Stages in development of eye of Cuttle-Fish (*Sepia*): in B the epidermis (*ep.*) has folded in to produce a vesicle (*v.*); in C a fold (*i.f.*) is growing out to form the iris; D is the adult eye: *f*, protective external fold; *i*, iris; *l*, *l*, outer and inner parts of lens; *r* and *s*, refracting and sensitive layers of retina.

eyes are used for seeing things at a distance, while the ocelli are used at close range. As focussing arrangements are entirely absent this would certainly be a great convenience.

The most familiar example of camera eyes among Molluscs is afforded by the Garden Snail (*Helix aspersa*, fig. 1038), where they are placed near the tips of the long front tentacles. It is extremely short-sighted, as we might expect in view of the fact that the lens is practically spherical and very close to the retina. The Pearly Nautilus possesses eyes which are constructed on the "pinhole camera" principle. There is no lens, and sea-water is admitted by a minute hole into the large internal cavity (fig. 1059). Large and complex eyes are found in the rapacious Squids and Cuttle-Fishes, and some idea of their structure and mode of development will be gathered from fig. 1059. A few of the Bivalve Molluscs possess numerous complex camera eyes situated on the edges of the mantle-flaps, as in the Scallops (*Pecten*), where they

are bright-red in colour. Their presence is possibly in relation to the fact that some species are active swimmers.

Before speaking of the camera eyes of Vertebrates, it may be well to mention certain simpler visual structures which are found in some of the most primitive members of that group. In the tadpole larva of a Sea-Squirt there is a simple cup-like direction-eye formed by thickening of the wall of the brain, and projecting into that organ (see fig. 1049, p. 38). Since the larva is transparent light-rays are able to reach it. The adult condition results from a remarkable series of modifications (see vol. iii, p. 421), which include simplification of the nervous system with loss of the brain-eye and brain-otocyst. The only compensation for this loss of vision consists in the appearance of a circlet of pigmented eye-spots round the openings by which currents of sea-water enter and leave the body.

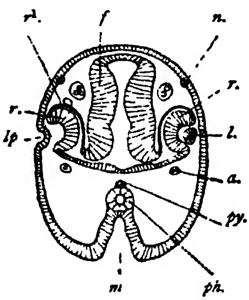


Fig. 1060. Diagrammatic Cross Section through the Head of a Tadpole to Illustrate the Development of the Eyes, enlarged. *f*, Fore-brain; *r* and *r*¹, retina and its external pigment-layer; *lp*, lens-pit; *l*, lens; *a*, an artery; *m*, mouth cavity; *n*, a nerve; *ph*, pharynx; *py*, pituitary body.

The visual organs of the transparent Lancelet (*Amphioxus*) are of even simpler kind. The so-called "eye" is merely a deeply-pigmented spot in the extreme front end of the nerve-tube, and there is in addition a series of similar but smaller spots in the floor of the nerve-tube behind the head-region.

The facts just mentioned prepare us for the statement that the ordinary camera eyes of Fishes and still higher Vertebrates are partly derived from the brain, and in this they differ from the camera eyes of Invertebrates, which are of epidermic nature. Two stages in the development of the Vertebrate eye are represented in fig. 1060. From either side of the fore-brain of the embryo an *optic vesicle* grows out towards the ectoderm, in which a corresponding pit makes its appearance. The end of the vesicle becomes as it were pushed in to form a double-walled *optic cup*, of which the inner and thicker layer is destined to produce the greater part of the retina, or sensitive eye-screen, while the outermost pigmented layer of this is derived from the outer part of the cup. The external ectodermic pit closes, and is pinched off as a vesicle, which lies in the optic cup (see right-hand side of figure), and ultimately thickens into the lens. The stalk of the optic cup becomes the

optic nerve. Since the brain itself is of ectodermic origin (see p. 20), it is clear that the parts of the eye so far mentioned are all derived from ectoderm. The rest of the eyeball, including its two outer coats and refracting contents (see vol. i, p. 57), are formed from the middle embryonic layer (mesoderm). This curious kind of development clearly suggests that in the remote ancestors of Vertebrates the eyes were internal projections from the brain, and received their light through the transparent tissues external to them, as is still the case in the single eye of the tadpole of a Sea-Squirt. The free ends of the visual cells (rods and cones) were directed towards the cavity of the brain. As in the course of evolution the brain became more and more complex, an opaque skull was developed for its protection, and the brain-eyes, having their supply of light thus cut off, were obliged, so to speak, to grow outwards. Subsequently they were improved into camera eyes by the development of a lens. Further improvements consisted in the evolution of eye-muscles, eyelids, and complex focussing arrangements. The visual cells (rods and cones) of the Vertebrate eye present the remarkable peculiarity of pointing *away* from the light, one result of the manner in which the retina is developed.

Fig. 10½.—Section through the Pineal Eye of a Tuatara (*Hatteria*), enlarged. *f*, fibrous covering; *l*, lens; *r*, *r*, retina; *b*, blood vessel; *o n*, optic nerve.

In Vertebrates, such as Fishes, which have to see under water, the lens of the eye is spheroidal, and one mark of the aquatic ancestry of the Amphibia is the possession of a lens of similar shape. But thoroughgoing land Vertebrates have lost this primitive character, for in them the lens is more or less flattened and biconvex, as an adaptation to seeing in air.

An extremely interesting and remarkable arrangement is found in certain bony fishes known as Double-Eyes (*Anableps*), native to the coasts and estuaries of tropical America. The name has been given because either eye, as seen from the exterior, is marked off into upper and lower halves by a dark transverse band. Dissection shows that the upper half of the lens is biconvex, and the lower half spheroidal. And since these fishes habitually swim at the surface, with only the lower part of the eye immersed, we can

only conclude that this half can see clearly in water, while the upper half has been so modified that distinct vision in air has also become possible.

Some of the Reptiles possess a more or less degenerate third or *pineal eye* on the top of the head (fig. 1061). It is connected with the roof of the 'twixt-brain. There seems good reason to believe that the ancestral Vertebrates had at least one visual organ in this position, probably serving as a means of detecting enemies attacking from above, a contingency to which aquatic forms are peculiarly liable. We may perhaps compare it with the internal brain-eye of the Ascidian tadpole, which also is unpaired and dorsal.

ANIMAL INSTINCT AND INTELLIGENCE

CHAPTER LIX

GENERAL PRINCIPLES—INSTINCT AND INTELLIGENCE IN HIGHER INVERTEBRATES AND VERTEBRATES

GENERAL PRINCIPLES

Having briefly surveyed the salient facts regarding the Nervous System and Sense-Organs we naturally pass on to the consideration of those higher manifestations of life known as Instinct and Intelligence, which play a very important part in the adjustment of animals to their surroundings. To do anything like full justice to the subject at least half a volume would be required, and it is only possible here to attempt a brief summary of general principles, adding to this a few typical illustrations. Many other examples, however, will be found in other parts of this book. As regards the present section, the writer wishes to acknowledge his great indebtedness to the works of Principal Lloyd Morgan, *i.e. Habit and Instinct*, *Animal Life and Intelligence*, and *Animal Behaviour*, to which are referred those readers who wish further information on this branch of zoology.

Something has already been said about Reflex Actions (see p. 9), which are comparatively simple responses to external stimuli. In very lowly animals, such as Animalcules (Protozoa), these, together with equally simple spontaneous actions, are sufficient to meet all the contingencies of existence. So apparently purposeful, however, are many of these actions, that some observers are inclined to ascribe mental powers to such forms. Either to prove or to disprove such a view is impossible, for we have no direct knowledge of the mind of any animal save Man, and can only make more or less probable guesses about other forms. We may feel pretty sure, however, that the evolution of the nervous

system through increasingly complex stages has been associated with a corresponding evolution of mind, and there is considerable justification for doubting whether animals devoid of a nervous system, or possessed of a very imperfect one, are endowed with more than a dim consciousness or awareness of existence, or are capable of manifesting either Instinct or Intelligence.

An animal which inherits the power of performing more or less complex actions helping to adjust it to its surroundings, independently of experience or instruction, is said to display Instinct, and such actions may be termed instinctive. They differ from Reflex Actions in being more elaborate, and many of them are partly or entirely spontaneous. But our knowledge is at present too incomplete to enable us to draw the line between actions which are of reflex character and those which are instinctive. It is only when dealing with the higher Invertebrates and the Vertebrates that we can use the latter term with any degree of certainty. The Birch-Weevil (see vol. iii, p. 394), for instance, certainly displays instinct when she constructs an elaborate leaf-funnel for the reception of her eggs. This very complicated piece of work is performed, so far as we know, with unerring certainty and without previous experience. Nor can the weevil have more than a hazy knowledge of the purpose of her work, which is probably done quite mechanically.

An animal is said to show Intelligence when it profits by experience, accommodating its actions to the exigencies of changed or changing surrounding. There is an inherited basis to such actions; it is the controlling power which makes them intelligent. The difference between Instinct and Intelligence is explained with admirable lucidity in the following passage from Lloyd Morgan (in *Animal Behaviour*): "Such an animal as a newly-hatched bird or an insect just set free from the chrysalis is a going concern, a living creature. It is the bearer of wonderfully complex automatic machinery, capable, under the initiating influence of stimuli, of performing instinctive acts. But if this were all, we should have no more than a cunningly-wrought and self-developing automatic machine. What the creature does instinctively at first it would do always, perhaps a little more smoothly as the organic mechanism settled down to its work—just as a steam-engine goes more smoothly when it has been running for a while; but otherwise the action would continue unchanged. Instinctive behaviour would

remain unmodified throughout life. The chick, however, or the imago insect, is something more than this. It affords evidence of the accommodation of behaviour to varying circumstances. It so acts as to lead us to infer that there are centres of intelligent control through the action of which the automatic behaviour can be modified in accordance with the results of experience. When, for example, a young chick walks towards and pecks at a lady-bird, the like of which he has never before seen, the behaviour may be purely instinctive; and so, too, when he similarly seizes a wasp-larva. . . . But when, after a few trials, the chick leaves lady-birds unmolested while he seizes wasp-larvæ with increased energy, he affords evidence of selection based on individual experience. And such selection implies intelligence in almost its simplest expression. We may say, therefore, that, whereas instinctive behaviour is prior to individual experience, intelligent behaviour is the outcome and product of such experience. This distinction is presumably clear enough; and it is one that is based on the facts of observation. But we must not fail to notice that, though the logical distinction is quite clear, the acquired modifications of behaviour, which we speak of as intelligence, presuppose congenital [*i.e.* inherited] modes of response which are guided to finer issues. We may say then, that where these congenital modes of response take the form of instinctive behaviour, there is supplied a general plan of action which intelligence particularizes in such a manner as to produce accommodation to the conditions of existence." The quotation just given implies, what is no doubt true that in the course of mental evolution Instinct does not *become* Intelligence, but is gradually *replaced* by it, *i.e.* inherited specialized behaviour is replaced more or less by self-specialized behaviour. The larger the amount of such replacement the greater the intelligence. And this enables us to understand the peculiar helplessness of the young of higher Mammals, especially those of our own species. The complex instincts of lower forms have been lost, and it takes a long time to learn how to act intelligently. The remark does not apply to all helpless young, for in some of these, *e.g.* in nestling birds, such instincts are only deferred. The influence of strongly-developed parental affection is noticeable in both cases.

To interpret the action of animals with any likelihood of accuracy it is necessary to avoid two extreme views of opposite kind. One of these ascribes almost human attributes to even the

lowest animals; it is a case of interpreting the observed in terms of the observer. The other and older view regards Man as the only intelligent animal, all the others being simply living machines worked by Instinct and Reflex Action. There has been in the past a great dearth of patient unbiassed observation on living animals, but the number of competent investigators is now fortunately increasing, and the results already obtained clearly point to the conclusion that extreme opinions in either direction are inadmissible.

The difference between Instinct and Intelligence may also be realized by taking some metaphorical illustration. Let us then compare the successful adjustments of an animal to its environment to the effective shots of a rifleman aiming at a series of targets. And let us also suppose that a certain minimum score is necessary for the maintenance of a bare existence, while marriage is only permitted as the reward of a good score. The shooting of such a rifleman would be comparable to the actions of an animal actuated by pure Instinct, if he were provided with a series of loaded rifles previously sighted and adjusted in such a way that he would merely have to press the triggers to mechanically secure a large number of points—a sort of "you-press-the-button-and-we-do-the-rest" arrangement. If the targets remained fixed the privileges attached to success would be easily secured. But the actions of life have to bring about adjustments to surroundings which are constantly altering, and this may be represented in the illustration by substituting moving targets for stationary ones. The purely "instinctive rifleman" would do pretty well if his targets moved but slightly, though bull's-eyes would be infrequent, and his total would be smaller. But with increasing movement the percentage of hits would dwindle till first of all the prize of matrimony would be denied him, and finally the score would be so small that even bare existence would not be permitted.

Our illustration can easily be modified to represent the gradual replacement of Instinct by Intelligence. By endowing our imaginary rifleman with increasing capacity to adjust his rifles, so as to secure a reasonable score with shifting targets, we make his shooting more and more intelligent, less and less instinctive. And were he simply given the loaded rifles, and left to learn the art of marksmanship for himself, success would require a high degree of intelligence. The loaded rifles would represent the gift of inheri-

YOUNG ORANG-UTANS (*Simia satyrus*

The Orang-utan, a man-like ape native to Sumatra and Borneo, is characterized by the great relative length of its arms, a peculiarity associated with purely arboreal habits. The long hair is of a reddish colour. Orangs are undoubtedly very intelligent, and the rounded intellectual-looking forehead gives a very human appearance. The mental powers of the Gorilla and Chimpanzee, however, are more considerable, though the powerful brow-ridges which these forms possess greatly detract from their personal appearance.

The Orang builds a kind of stick-nest in the fork of a tree as a temporary shelter, from which it does not sally forth to feed until the day is well advanced. Small family parties are commonly found associated together, though the male appears to lead a solitary life during a large part of the year. The young are as helpless as those of the human species, and those which have been brought up in captivity present many similar traits. Their wants are expressed by loud lamentations, and they protest loudly if their food is not to their taste. They also greatly appreciate being nursed and "cuddled". Unlike human infants, however, they are eager to be washed and combed.

YOUNG ORANG-UTANS (SIMIA SATYRUS)

tance; but were there no profiting by experience most of the shots would go wide. Parental care might be here symbolized by supposing the raw beginner protected and instructed by an expert shot until the necessary experience had been acquired.

We do not know how far down in the scale of animal life some sort of consciousness exists, but the dawn of intelligence is marked by the appearance of what Lloyd Morgan calls "effective consciousness", *i.e.* a realization of existence which enables more or less successful adjustments to a changing environment.

In ourselves we find Intelligence reinforced by Reason, the "ideational stage" in mental evolution, where actions depend upon motive, instead of being due to mere impulse dictating certain sorts of behaviour "on the spur of the moment". It involves appreciation of abstract ideas with powers of reflection and deliberation, leading us to trace the relations between cause and effect, and to construct ideals of existence by which our conduct is more or less regulated. The dim beginnings of Reason are probably to be found among the higher animals, but the body of facts with which we are at present acquainted is far too small to justify positive statements or wide-sweeping generalizations.

INSTINCT AND INTELLIGENCE IN HIGHER INVERTEBRATES (INVERTEBRATA)

The most instructive cases so far investigated are to be found among Insects (Insecta) and Molluscs (Mollusca), and it will be enough for our present purpose to briefly describe a few of these.

INSTINCT AND INTELLIGENCE IN INSECTS (INSECTA).—A good example of the stereotyped nature of complex instincts is given by Fabre (in *Souvenirs entomologiques*) in his account of one of the Mason-Bees (*Chalicodoma muraria*) native to South Europe. The female makes a nest consisting of nine or ten cells placed one on top of the other, using cement made of a mixture of earth and saliva, to which little stones are added. After each cell is built it is stored with honey and pollen, after which an egg is laid in it, and a roof is added. The entire series is then thickly covered with cement till the nest assumes a hemispherical form. The three operations of building, storing, and egg-laying which take place in regard to each cell follow one another with automatic regularity, and there is no harking back to an earlier stage. For conditions

artificially imposed with a view to altering the order do not succeed in this, as they would do if the actions were of very intelligent kind. For example, a nest with fully-constructed top-cell partly stored was substituted for the original nest in which the uppermost cell had only been commenced. The bee did not apparently detect the imposture, and proceeded to raise the walls of the substituted cell till it was one-third greater than the normal height. In another experiment a bee had completed the construction of a cell, and was preparing to store it, when another nest with an incomplete top-chamber was substituted. On her return with honey and pollen she appeared greatly puzzled at the change, and finally deposited her load in the nest of a neighbour. The result of another similar experiment was somewhat different, for the bee removed the roof of the last complete cell and stored this a second time, afterwards laying a second egg in it. The last two experiments seem to prove the existence of a certain infusion of intelligence, as shown by the attempts to meet the altered circumstances, though these attempts were not of very satisfactory kind. It is somewhat remarkable that this bee is apparently unable to recognize its own nest, though we must not forget that its visual powers are of different kind from our own, but it has a well-marked memory for localities, returning to the spot selected for building-purposes from considerable distances. Fabre also showed that individuals removed as far as four kilometres from their nests, into what was probably unknown country to them, were able to find their way home. Quite a number of animals are endowed with a strong "homing faculty" of this kind, but how far this may be due to a "locality sense" which cannot be explained by applying the known principles of human physiology, it is as yet impossible to say. In this particular instance, even if we were to assume that the bees had some previous acquaintance with the distant place to which they were taken, we should still be quite unable to explain exactly *how* they got home. Locality-memory, however, would seem to imply some amount of intelligence. Readers desiring further details of the fascinating observations and experiments by Fabre on Mason-Bees and many other insects are referred to the original work, or the translation of the same which has recently appeared.

Suggestions have more than once been made in the course of this book as to the kind of investigation which amateur naturalists

might profitably attempt. The habits of Insects and other higher Invertebrates offer an inexhaustible and intensely-interesting field to multitudes of such workers. Accurate observations recorded with scrupulous exactness are here badly needed, and those who enlarge our knowledge in this direction are contributing to the advance of two branches of knowledge, zoology and the science of mind (psychology), not to mention sociology and education both of which are intimately connected with the latter.

It is indispensable that observations on instinct and intelligence should be made with a perfectly open mind, and not with the object of collecting material for the support of this or that view. And it is peculiarly necessary to remember that the mental standard of human beings can only be applied with many reservations in explanation of the actions of animals, especially when dealing with creatures like Insects which, though of highly complex structure, have specialized on lines of their own. A series of observations made in this spirit, and which are not only of the utmost value but of absorbing interest, have been recorded by Dr. and Mrs. Peckham (*On the Habits and Instincts of the Solitary Wasps*). These insects have attracted much attention on account of their habit of storing up caterpillars, flies, spiders, &c., for the benefit of their progeny, the victims having previously been stung (see vol. iii, p. 391). Instincts of very complex nature are here involved, but the zoologists just mentioned have shown that these instincts are not so stereotyped as commonly supposed, there being a certain amount of adaptability to circumstances, which is strong presumptive proof of some degree of intelligence. Pure instinct is manifested by the fact that any particular species of these wasps is always found to select the same kind of prey, and, for a given species, there is so much uniformity in the mode of nest-construction, the way of disabling the victims, the manner of taking them into the nest, &c., that instinct is undoubtedly the dominant factor. But, except in regard to the kind of prey, there is a sufficient amount of adjustment to varying circumstances to warrant the conclusion that intelligence also plays some part in the complex series of operations. It appears, for example, that the prey is not uniformly stung in the nerve-cord, as once believed, and it may be killed instead of paralysed by its injuries, proving in either case suitable food for the larvæ. This certainly discounts the view that this part of the series of actions is stereotyped by instinct.

And a convincing proof of the power of profiting by experience which constitutes intelligence is given in a letter of Dr. Peckham's, quoted by Lloyd Morgan (in *Animal Behaviour*), in reference to a species (*Sphex ichneumonea*) which preys upon grasshoppers, and after leaving them a short time while she makes an excursion into the nest, returns and drags them in by their feelers. One individual, being several times thwarted in her storing work by removal of the victim to a short distance when she was in the nest, soon learnt the inadvisability of losing sight of her booty, and either at once dragged it into the hole or, straddling over it, substituted pushing for pulling.

One of the most remarkable points about the nesting-instinct in so many solitary insects is the elaborate provision made for the welfare of offspring which will never be seen, and which commonly require food of quite different nature from that taken by the adult. The parent would seem to be urged on by irresistible impulses, and can hardly be supposed to realize the meaning of its work, except perhaps in a very dim sort of way. Butterflies and Moths illustrate the food-question very clearly. It is true that they do not construct and store nests, like the solitary wasps just mentioned, but they instinctively lay their eggs on special sorts of plant, upon the leaves of which their voracious offspring are destined to feed. A Peacock Butterfly (*Vanessa Io*), for example, selects a nettle for the purpose, but her own food consists of nectar drawn from the recesses of flowers by means of suctorial mouth-parts, differing greatly from the powerful biting jaws of the leaf-eating caterpillar. It is almost impossible to believe that remembrance of her own larval days guides to the choice of a suitable place for egg-laying, for the caterpillar is conv -ted into the adult by a series of revolutionary changes which amount to reconstruction.

INSTINCT AND INTELLIGENCE IN MOLLUSCS (MOLLUSCA).—Comparatively few observations have been made upon the members of this group, some of which are very highly organized. Several good illustrations of both instinct and intelligence have, however, been recorded.

The Octopus is one of the highest Molluscs, and appears to be a very intelligent creature. Schneider saw a young one seize a hermit-crab and then let it go, being stung by the zoophytes covering its shell. For some time at least this individual was observed to avoid hermit-crabs, having learnt to associate them

with painful sensations. Other Octopi manifested still greater intelligence, for they pulled hermits out of their shells, taking care not to touch the zoophytes, realizing apparently that these were the stinging element. More remarkable than this is an observation made by Madame Jeannette Power. This lady on one occasion saw an Octopus, that held a stone by one of its arms, watching a large bivalve (*Pinna*) of which the shell was beginning to open. When this operation was complete the Octopus quickly inserted

Fig. 1062.—A Limpet (*Patella vulgata*) leaving its Scar at Ebb-tide

the stone between the valves so as to prevent them from coming together again, and then proceeded to make a meal of the helpless bivalve.

Some of the Gastropods possess a well marked "homing instinct", a particularly good example of this being afforded by the Common Limpet (*Patella vulgata*, fig. 1062). As elsewhere described (see vol. ii, p. 197) this creature lives on a particular spot, which in course of time becomes a more or less well-marked "scar", to which it can hold so firmly as to defy waves and tide. From this home it wanders out to feed when uncovered by the water, and also when well covered. From such excursions, which may extend to a distance of several feet, it later on returns to settle down again on the scar, the surface

traversed being often very irregular and covered with acorn-barnacles. When the animal gets back to the scar it of course arrives wrong way on, so to speak, and it quickly shuffles round so as to get into the proper position. A memory of locality certainly exists, and this would seem to imply intelligence. In the course of time a Limpet acquires a very accurate knowledge of the topography of a fair-sized area around its home, and if picked up when on the crawl and placed within this area is able to get home, though the time taken varies considerably. Exactly *how* it gets home we do not know. The simple cup-like eyes cannot render assistance, nor can we very well suppose that the otocysts help to guide it. Experiments appear to demonstrate that the animal does not smell its way back, and we are therefore reduced to touch, or to a "locality sense", or to both. The most obvious organs of touch are the two large tentacles on the head, with which the Limpet constantly touches the rock as it crawls, and it is no doubt by means of these that a good deal of the topographical knowledge is acquired. But as it can get home without the aid of these organs there must be some other organs of guidance. The edge of the mantle-flap is provided with a very large number of small tentacles which can be stretched out and actively moved, as they are sometimes, if not always, when the animal is adjusting itself on its scar. These perhaps have something to do with the matter, and so may still other sense-organs, but further investigation is required. The problem here to be solved, like most of those connected with locality-knowledge, is of a particularly baffling kind, though not to be regarded as insoluble. The Garden-Snail (*Helix aspersa*) is another Mollusc possessed of a "homing instinct"

INSTINCT AND INTELLIGENCE IN VERTEBRATES
(VERTEBRATA)

There is here an almost unlimited amount of material which might be discussed, but a few examples must suffice.

WARNING COLORATION.—A large number of animals possessed of noxious properties advertise their objectionable nature by means of bright though somewhat crude colours, and simple but striking patterns, the net result of which is to render them extremely conspicuous (see vol. ii, p. 301). Such are the

striped "blazer" of the Wasp, and the spotted jacket of the Lady-Bird. Unless very hard pressed by hunger it appears that the foes of animals so coloured and marked give them a wide berth. But without careful observation and experiment it would remain an open question whether this resulted from Instinct or Intelligence, or a mixture of the two. The cases which have so far been properly investigated appear to prove that Intelligence here comes into play, and that a young animal has to learn from experience that some things are good to eat and others not. The thorough and long-continued researches of Lloyd Morgan upon artificially-hatched chicks definitely prove that they at least have to acquire such useful knowledge for themselves. He thus describes (in *Animal Behaviour*) how some of his chicks learnt that alternate bands of black and orange, as possessed by the caterpillars of the Cinnabar Moth, are associated with disagreeable sensations:—"The following experiment was made with young chicks. Stripes of orange and black paper were pasted beneath glass slips, and on them meal moistened with quinine was placed. On other plain slips meal moistened with water was provided. The young birds soon learnt to avoid the bitter meal, and then would not touch plain meal if it was offered on the banded slip. And these birds, save in two instances, refused to touch cinnabar caterpillars, which were new to their experience. They did not, like other birds, have to learn by particular trials that these caterpillars are unpleasant. Their experience had already been gained through the banded glass slips; or so it seemed. I have also found that young birds who had learnt to avoid cinnabar caterpillars left wasps untouched."

Nest-Building in Birds.—There can be no reasonable doubt that in its main features the nest-building of birds is a matter of instinct. One of the best proofs of this is afforded by cases where individuals kept in captivity from the time of hatching, under conditions which excluded the possibility of instruction or imitation, have nevertheless constructed nests of the kind proper to their species. Further experiments, however, are much to be desired, especially on birds which indulge in architecture of such characteristic kind as to be quite unmistakable. It would, of course, be necessary to make the nesting conditions in such cases as natural as possible. Other instincts, tending to the benefit

of the eggs or young, are often associated with that for nest-building. Of this the Eider-Duck (*Somateria mollissima*, fig. 1063) may be taken as an example. Egg-laying and building are here not consecutive acts, but the former takes place at intervals during the latter, in a somewhat variable fashion. Three successive stages are shown in the illustration, which is taken from photographs by Mr. R. A. L. Van Someren. The first represents four eggs resting in the incomplete nest, and the second (on a larger scale) the complete down-lined nest with its full complement of eggs. The third figure shows the same nest during the temporary absence of the mother-bird, and illustrates an interesting associated instinct. Before leaving her duties she had pulled the down over the eggs, so as to cover them completely, an act distinctly conducive to their welfare. For, snugly tucked up under their "eider-down quilt", they were not only kept warm, but also, as the figure clearly proves, effectively screened from observation.

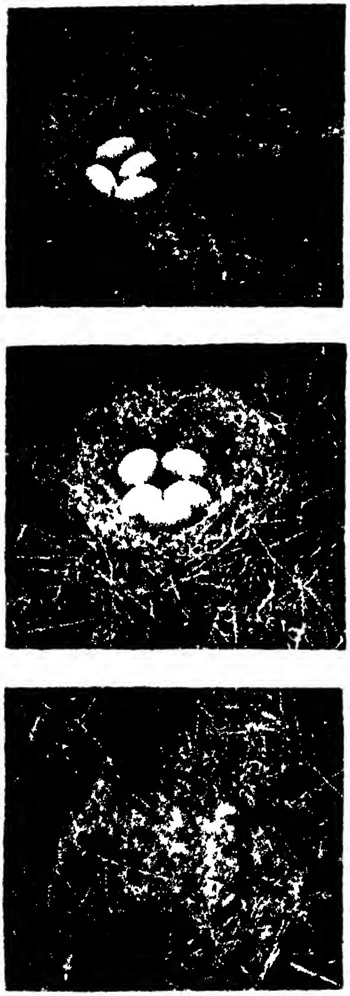


Fig 1063.—Nest of the Eider Duck (*Somateria mollissima*). See Text.

But although nest building is almost certainly instinctive in the main, it is subject to modification in individual cases in ways which vouch for the intelligence of the builders. And such modification may affect the style, materials, and place of construction. Often-quoted illustrations are those of the House-Swallow and House-Martin, which have taken advantage of the evolution of human civilization so far as concerned with domestic architecture.

This change of habit, of course, took place in the remote past, but the following very interesting modern example of precisely similar kind is given by Headley (in *The Structure and Life of Birds*):—"The Palm Swift in Jamaica till 1854 always built in palms. But in Spanish Town, when two cocoa-nut palms were blown down, they drove out the Swallows from the Piazza of the House of Assembly and built between the angles formed by the beams and joists." Of other such cases Newton thus writes (in *A Dictionary of Birds*):—"But though in a general way the dictates of hereditary instinct are rigidly observed by Birds, in many species a remarkable degree of elasticity is exhibited or the rule of habit is rudely broken. Thus, the noble Falcon, whose ordinary eyry is on the beetling cliff, will for the convenience of procuring prey condescend to lay its eggs on the ground in a marsh, or appropriate the nest of some other bird in a tree. The Golden Eagle, too, remarkably adapts itself to circumstances, now rearing its young on a precipitous ledge, now on the arm of an ancient monarch of the forest, and again on a treeless plain, making a humble home amid grass and herbage. Herons also show the same versatility, and will breed according to circumstances in an open fen, on sea-banks, or (as is most usual) on lofty trees. Such changes are easy to understand. The instinct of finding food for the family is predominant, and where most food is, there will the feeders be gathered together. This explains, in all likelihood, the associated bands of Ospreys or Fish-Hawks, which in North America breed (or used to breed) in large companies where sustenance is plentiful, though in the Old World the same species brooks not the society of aught but its mate."

MIGRATION OF BIRDS.—Nothing can be more familiar than the fact that innumerable species of birds undertake periodic journeys, often of extreme length, from one region to another, and at the same time nothing in the entire realm of natural history is more mysterious. Broadly speaking, the same migrant species has its own line of travel between its two places of residence. The Golden Plovers, for example, of the northern part of North America, fly south to the north of South America *via* the Bermudas and Antilles. The paths of a number of species are more or less coincident, in many cases, to form what is known as a "migration route", and some of these routes

have been determined with some approach to accuracy. A vast number of facts concerning migration have already been collected, and these receive large additions every year, so that in the course of time we may expect to have a fairly complete knowledge of the movements of many migratory birds. To discover *how* they find their way is a much more difficult problem, especially in cases where there can have been no previous experience. Many of them, *e.g.* the Common White Stork (*Ciconia alba*), "assemble" before migration, as if to practise their powers of flight, and the writer once saw the roof-ridges in the street of a midland town "lined" with hundreds of swallows at 6 a.m. one morning, less than two hours after which all had disappeared. It has been suggested that the old birds impart geographical knowledge to the young, and also that the migrant flocks are "personally conducted" by experienced leaders. But many well-ascertained facts militate strongly against such views, at any rate for certain species. Some young birds go off by themselves, even the first time they migrate, and this may take place under conditions which preclude the possibility of their having previously acquired information from their elders. The Common Cuckoo (*Cuculus canorus*), for example, winters in Africa, and, as everyone knows, its offspring are reared by other birds. The old Cuckoos have all left this country by the end of August, and the young ones take their departure later. In such a case we cannot doubt the existence of a "migratory instinct", but how far this is modified by intelligence has yet to be determined. We are equally ignorant as to the sense-organs which are the agents of the instinct, and its possible modifications by intelligence, even more than we are in the cases of insects and molluscs which possess a keen sense of locality. We ourselves are not entirely devoid of a faculty of the kind, and it appears to be comparatively well developed in savage races. It is to be hoped that extended observation and experiment will some day throw more light upon the subject, till when it will be wise to suspend our judgment, and remain in a critical attitude, rather than indulge in premature generalization. It is scarcely necessary to add that there is room for a host of unprejudiced observers in this field of work.

WHITE STORKS (*Ciconia alba*) ASSEMBLING FOR MIGRATION

The seasonal Migration of many birds is a phenomenon familiar to all, and one which, in spite of much research, is still but little understood. Food-supply has no doubt much to do with it, but the reasons for migration are the least mysterious part of the matter. *How* birds are able to find their way over vast stretches of land and sea to regions suitable for their purposes is at present quite beyond our comprehension. In most cases it appears that the young birds are the first to depart on what must be for them an unknown journey, which greatly adds to the difficulty of the problem to be solved. One of the best-known migratory birds is the White Stork, the rough stick-nests of which are such common objects on roofs and chimneys in Holland, Denmark, and North Germany. The locality-sense is strongly developed, for year after year a nest is tenanted by the same pair of birds. They arrive in spring, leaving again in late summer, by which time the young are well grown. Before their departure they "assemble" in large numbers on the meadows, and fly away in troops, some of which have been estimated to include as many as five thousand individuals. They winter in Africa, some of them getting as far south as Cape Colony.

WHITE STORKS (CICONIA ALBA) ASSEMBLING FOR MIGRATION

ASSOCIATION OF ORGANISMS—THE WEB OF LIFE

CHAPTER LX

ASSOCIATION OF ORGANISMS—GENERAL PRINCIPLES—ANIMALS AND PLANTS

GENERAL PRINCIPLES

The study of natural science during the last half-century has advanced so rapidly that it is no longer possible for one man to grapple seriously even with a single subject, and there is an ever-increasing tendency towards specialization. No doubt the sum of our knowledge is thereby constantly being increased at a rate which would otherwise be impossible, but there is another side to the question. For extreme specialization is somewhat apt to lead to a neglect of general principles, and to a more or less complete loss of the sense of proportion. To be unable to see the wood on account of the trees is bad enough, but to have one's vision restricted to a single tree, or perhaps a single branch, is very much worse. In no department of knowledge is the cramping tendency of specialization more apparent than in natural history. There seemed at one time a chance of establishing a science of Biology, designed to deal with both plants and animals, but this has now been merged into botany on the one hand and zoology on the other, and many of the important relations that exist between plants and animals are not given the prominence which they undoubtedly deserve. This cannot altogether be helped, but even under existing circumstances it is both desirable and possible that work of specialist kind should be preceded by studies of a wider and more general nature. This is one of the aims of the new subject of Nature-Study, so far as biology and geology are concerned, another object being to foster that intelligent interest in and accurate observation

of natural objects upon which much of the future happiness of our embryo citizens will depend. If properly taught as a connected whole, and not as a string of isolated facts (to be "learnt"), this subject ought to fare better than physiography and general elementary science, which, though designed with the laudable intention of giving a broad foundation in non-biological science, are now somewhat discredited.

The relations which bind together the innumerable plants and animals now living on the globe are so numerous, and often so complex, that from this point of view the world has been compared to a spider's-web of elaborate texture, in which all the threads are directly or indirectly connected, so that when one is touched the entire structure is thrown into vibration.

It is not within the scope of this work to deal with the complex relations which link together the members of the vegetable kingdom, and students who desire information of this kind are referred to the English edition of Schimper's *Plant Geography*, to Kerner von Marilaun's altogether admirable book *The Natural History of Plants*, and also to Scott Elliot's *Nature Studies*, which gives an excellent account of the leading facts and principles in small compass. But it may be well to attempt here a brief description of the salient features which mark the relations existing between plants and animals. This is much more fully dealt with by the authors just mentioned.

PLANTS AND ANIMALS

It may not be superfluous to remark here that the vegetable world is divided into the following great groups, beginning with the highest:—1. SEED PLANTS (Spermaphyta), including most of the large and obvious forms, such as ordinary forest-trees and the inhabitants of our flower-gardens. 2. FERN-LIKE PLANTS (Pteridophyta), comprising not only ferns, but also horse-tails, club-mosses, &c. 3. MOSSES AND LIVERWORTS (Bryophyta). 4. LOWER PLANTS (Thallophyta), in which the body is not divided into stem, root, and leaf, or such a division is only incipient. Multitudes of Thallophytes are minute or microscopic, and in any case they may broadly be assigned to one of three sub-groups: (*a*) *Algæ*, embracing brown, green, and red sea-weeds (with a smaller number of freshwater weeds), with a host of smaller

forms living not only in water but in most damp places; (*b*) *Fungi*, including toad-stools, moulds, mildews, the microscopic yeast-plants, and the still smaller bacteria; and (*c*) *Lichens*, which are intimately connected communities of algæ and fungi.

All these plants, except fungi (and a few seed-plants), contain leaf-green or chlorophyll, a substance of great biological importance, as elsewhere explained. It is convenient to distinguish forms which possess it as "green plants", though the chlorophyll

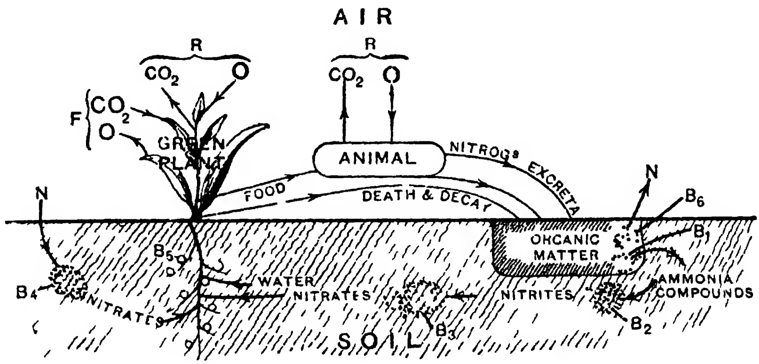


Fig. 1064.—Relations between Animals and Plants: arrows indicate the taking in or giving out of various substances

Both green plant and animal take in oxygen (O) and give out carbon dioxide (CO_2) in the course of respiration (R). The animal feeds on plants, and by nitrogenous excretion and ultimate death adds to the store of organic matter in the soil. The green plant in the course of feeding (F) takes in carbon dioxide (CO_2) from the air, returning oxygen (O), and also takes up water with dissolved salts from the soil; its dead parts contribute to the store of organic matter in the soil. The groups of bacteria B_1, B_2 respectively produce ammonia compounds, convert these into nitrites, and these again into nitrates. The bacteria B_4, and the higher fungi B_5 fix the free nitrogen (N) of the air, with production of nitrates. The bacteria B_6, in the absence of oxygen, decompose organic matter with liberation of free nitrogen (N).

may be obscured by the presence of other pigments, as, for example, in brown and red sea-weeds.

Relations between Organisms and the Constituents of the Atmosphere (fig. 1064).—In considering this question it must not be forgotten that the gases which are mixed together in air are also found dissolved in both fresh and salt water, and the relations between these dissolved gases and aquatic organisms are pretty much the same as those subsisting between ordinary air and land organisms. The most important of these gases are carbon dioxide (carbonic acid gas, CO_2), oxygen, and nitrogen. It has already been explained in the section on Breathing (vol. ii, p. 379) that plants and animals respire in the same way, taking in oxygen to facilitate the breaking-down processes which continually go

on in the body, and giving out carbon dioxide as a product of waste. It is quite a mistake to suppose that plants "breathe in carbon dioxide and breathe out oxygen", as often supposed. If there were not some compensating arrangement, it is clear that the amount of oxygen in air would rapidly diminish and the quantity of carbon dioxide rapidly increase. But it appears that this is not so, for the composition of air remains practically the same, at least for very long periods of time, though probably in earlier periods of the earth's history its constituent gases were in different proportions from what is now the case. This constancy of composition at the present day is intelligible when we remember how green plants feed, and of what their food consists. Such plants, in fact, bridge over in a fashion the gulf between non-living and living matter. For their food consists of carbon dioxide (obtained from the air), and water in which are dissolved certain substances of simple kind, foremost among these being nitrogen-containing compounds known as nitrates, of which saltpetre is a well-known example. In any sort of tree, shrub, or herb the carbon dioxide is taken in by the leaves (and the green part of the stem), while the roots absorb from the soil a watery solution of nitrates, &c., so dilute as to be comparable to the ordinary drinking water of most districts. These simple constituents of the food are converted step by step into the living substance of the plant by the agency of that substance itself. The first step in this series of up-building processes takes place in the leaves (and the green parts of the stem), and consists in a reaction between carbon dioxide and water, giving rise to a substance which is more complex in nature than either of them. This can only go on in daylight and in the presence of chlorophyll, which in some way not clearly understood enables the living substance associated with it to press the energy of sunlight into its service for the purpose of building up a comparatively complex substance from simple ones. And this first step in the manufacture of living matter is accompanied by the liberation of free oxygen into the surrounding air as a by-product. For the carbon dioxide and water, which are the raw materials in this work, contain more oxygen than is required for the purpose, and the surplus passes away to the exterior. It therefore follows that green plants in the course of their feeding (1) take carbon dioxide *from* the air, and (2) give out free oxygen *to* the air. And these

gases are respectively taken in and given out in such proportions that the amount of carbon dioxide in the air does not rapidly grow larger, and the amount of free oxygen rapidly get smaller, as would undoubtedly be the case if the results of breathing were not compensated.

The action and reaction between organisms and the air also involve chemical processes which have to do with nitrogen, and in which a leading part is played by various bacteria which live in the soil. Green plants get the nitrogen which they require for feeding purposes in the form of dissolved nitrates, which are derived from more than one source. It is a familiar fact that ordinary earth or soil, such as is to be found in a garden, is more or less dark in colour, largely as the result of the presence of organic matter. This partly consists of the remains of organisms which have died and decayed, and partly of substances derived from the nitrogen-containing excreta of animals. The rotting, decomposition, or breaking down of such materials is the result of chemical changes brought about by certain bacteria in the presence of oxygen, with production of ammonia compounds. Another set of bacteria convert these compounds into salts known as nitrites, from which nitrates are then produced by the action of still another group of bacteria. The nitrates serve as food to green plants, which in their turn are devoured by animals. We thus see that by the death and decay of organisms material is produced which helps to build up the bodies of new generations. This, however, is not the only source of nitrates in the soil, for what are known as *nitrifying* bacteria are there present, which possess the remarkable power of abstracting free nitrogen from the air, and causing it to enter into combination. There is another arrangement by which, in leguminous and a few other plants, the same end is attained. If, say, a pea or bean-plant is dug up, and the earth washed away from its roots, these will be found to bear a number of rounded thickenings. Within each such "root-tubercle" live a number of microscopic fungi (possibly bacteria) that appropriate the free nitrogen of the air which circulates in the soil, employing it to build up nitrates. We have here a striking example of Mutualism (symbiosis), *i.e.* the intimate association of two organisms for their common benefit. The leguminous plant has a supply of nitrates ready to hand, while the tubercle-fungus is sheltered, and no doubt nourished.

It is clear that by the action of nitrifying bacteria and tubercle-fungi the nitrogen of the air is steadily diminished, but here again we find a means of compensation. For there are certain *denitrifying* bacteria, which, in the absence of oxygen, act upon decaying organic matter in such a way that free nitrogen is liberated.

RELATIONS BETWEEN THE NUTRITION OF PLANTS AND ANIMALS. —A little reflection will show that animals are entirely dependent upon plants in the matter of food. This is obviously so as regards purely vegetarian animals, while carnivorous forms are indirectly dependent upon the vegetable world. Many flesh-eaters feed entirely upon vegetarians, but if they prey upon other flesh-eaters, and these again upon still other carnivorous creatures, and so on, we get to plants in the end.

Plants, considered as food for animals, have been concerned in the evolution of burrowing, climbing, parachuting, and flying forms, especially the last three. (For details, see vol. iii, pp. 231, 281, 292.)

On the other hand, animals contribute to the store of plant food. For, as we have already seen (pp. 65-67), they breathe out carbon dioxide, which green plants take up, while their nitrogenous excreta and dead bodies are partly converted into nitrates, which the same plants are able to use for the purposes of nutrition.

There are also a number of CARNIVOROUS PLANTS, which do not altogether rely upon simple substances as food, but are provided with "traps" for the capture and digestion of insects or other small creatures. One of Darwin's most interesting books (*Insectivorous Plants*) is devoted to these forms, some of which are native to our own country, while several others may be seen in botanic gardens. One of the simplest kinds of arrangement is seen in the Butterwort (*Pinguicula*), that is often to be found growing in damp places among our mountains. The pale-green slippery leaves are arranged in a rosette, from the centre of which violet flowers grow up. Small flies alighting on the leaves are held fast by a sticky fluid, secreted by a multitude of little knobbed hairs which project from the surface. The edges of the leaves then curl over the prey, and there is an increased exudation of the fluid in question, which acts very much like gastric juice, converting the flesh of the booty into a soluble form that is then absorbed as food. The widely distributed members of the Sundew family (*Droseraceæ*) exhibit greater specialization in

relation to the catching of insects than the Butterworts, though the means employed are essentially the same. Our native forms, the Sundews (species of *Drosera*), are fairly common in marshy places, and are often found growing side by side with the Butterwort. Here, again, the leaves are arranged in a rosette, from the centre of which rises a stem bearing a number of small flowers. The end of each leaf is thickly studded with long reddish "tentacles", shaped something like pins, upon the heads of which are little drops of sticky fluid that glisten like dew (fig. 1065). Should an unfortunate insect alight on one or more of these tentacles it sticks fast, other

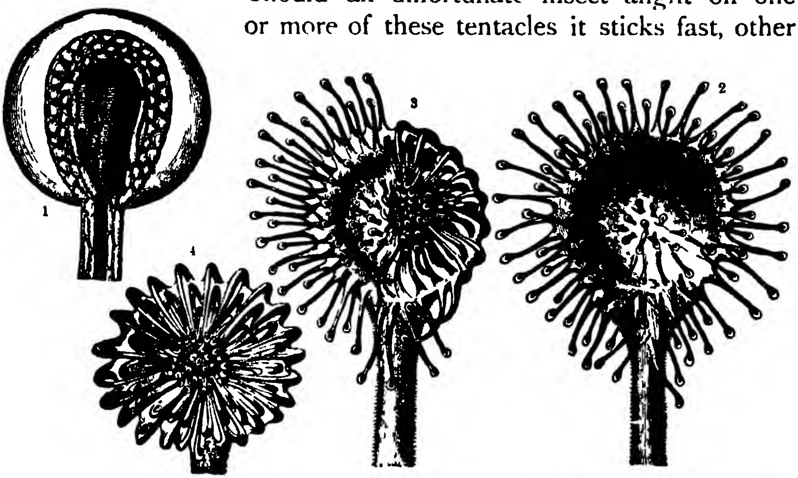


Fig. 1065.—The Sundew (*Drosera*). 1, Tip of a tentacle greatly enlarged, showing viscid secretion. 2, 3, 4, Leaves, enlarged, showing tentacles fully extended, partly approximated, and entirely approximated

tentacles bend towards it, there is an increased flow of the digestive juice, and the final result is the same as in a Butterwort.

Venus' Fly-Trap (*Dionæa muscipula*), growing on marshy ground in the east of the United States, is a near relative of our Sundews, but its "traps" are much more elaborate (fig. 1066). The end of each leaf is divided into halves which can move towards each other almost as on a hinge, while their edges are fringed with bristles. The upper side of each half is studded with small violet hairs, which secrete a digestive fluid, and three large sensitive hairs project from its centre. If an insect happens to visit one of these leaves, and touches one or more of the six sensitive hairs, the result is somewhat dramatic. For the halves of the leaf close rapidly together, the bristles on their edges inter-

locking, so that a very perfect trap is constituted, in which there is plenty of room for an average victim, since as the two halves move together they become concave towards each other. As in the other cases, digestion and absorption complete the tragedy.

Among the most notorious of carnivorous forms are the widely-distributed Pitcher Plants, in which the leaves are hollowed into structures which may be described as a combination of lure, pit-

Fig 1066.—Venus Fly Trap (*Dionæa muscipula*)

fall, and stomach. Such are the species of *Nepenthes*, which range from Madagascar through South Asia and the East Indies to the Philippines. In this case the lidded pitchers look something like hot-water jugs, and are attractively coloured. The way in which they serve their purpose is thus described by Kerner (in *The Natural History of Plants*):—"The bright pitchers of *Nepenthes*, visible from afar, are sought, just as flowers are, by insects, and probably by other winged creatures as well; and this occurs all the more because there is a copious secretion

of honey by the epidermal cells upon the under surface of the lid, and on the rim round the mouth of each pitcher. The swollen and often delicately-fluted rim, in particular, drips and glitters with the sugary juice, and it would be permissible in this connection to speak of a honeyed mouth and sweet lips in the most literal sense of the words. Animals which suck honey from the lips of *Nepenthes* pitchers wander, as they do so, only too readily upon the interior surface of the orifice. But the inner face is smooth and precipitous, and rendered so slippery by a bluish coating of wax that not a few of the alighted guests slip down to the bottom of the pitcher and fall into the liquid there collected. Many of them perish in a short time; others try to save themselves by climbing up the internal face of the pitcher, but they always slip again on the polished, wax-coated zone, and tumble back once more to the bottom." In some species the inwardly bent rim of the pitcher is fringed with sharp teeth which curve downwards and facilitate entry but forbid exit.

Another very interesting Pitcher-Plant (*Sarracenia variolaris*), native to the marshes of Alabama, Carolina, and Florida, presents arrangements of somewhat different kind. It possesses a rosette of elongated hollow leaves, of which the ends bend sharply over like hoods. The narrow opening of a pitcher is just under the hood, from which a little flap hangs down. Allurement by colour is not wanting, for though most of each pitcher is green, its hooded top is veined with red, and there are purple blotches here and there. In this region, too, there are numerous translucent patches between the veins, which from inside the pitcher must look like openings or "windows". As in *Nepenthes*, honey is provided on the inner surface of the hood and round the margin of the aperture, from which a sugary ridge runs right down to the ground, serving as an attractive but fatal pathway to many wingless insects, especially ants. The pitcher is a pitfall of the deadliest kind, for its interior is clothed with slippery overlapping scales, of which the narrow pointed ends are directed downwards, so that insects, once imprisoned, are quite unable to climb out again. And if a winged insect tries to fly out it naturally makes for the apparent windows in the hood, for the actual opening faces downwards and is veiled in darkness, and in most cases falls back exhausted into the putrid

fluid which fills the lower part of its prison. The unfortunate victims are not digested, as in *Nepenthes*, but either drown or starve, after which their bodies decompose to form a sort of liquid manure, parts of which are no doubt absorbed as food. Yet, strange to say, a few flies, and a small moth, regularly lay their eggs in the decomposing mass contained in these pitchers, and possess climbing-irons, so to speak, which enable them to get out again with the greatest ease. One such form is a species of Blow-Fly (*Sarcophaga Sarraceniæ*), own cousin to the speckled nuisance (*S. carnaria*) that lays her eggs in our meat, and to which we give the same name. Each foot of this fly is possessed of a long and sharp claw, which can be pushed between the scales of the pitcher, and firmly fixed into the underlying tissue. The maggots which hatch out of her eggs feed on the putrefying substances surrounding them until they are full grown, when they easily get out of the pitcher, not by climbing, which would be impossible in their case, but by the simple device of eating a hole in the wall. Once outside, they enter the ground, and there pass into the motionless pupa stage, from which the adult fly later on emerges. The small moth (*Xanthoptera semicrocea*) for which the Sarracenia pitchers have no terrors is adapted for climbing in much the same way as the Blow-Fly. For each of the second legs possesses a pair of long sharp spines at the end of its shin (tibia), while two pairs of such spines are similarly situated on each of the hind-legs. The caterpillars do not, like the fly-maggots, eat their way out of the pitcher, but climb out, though in quite a different way from their mother. Their solution of the problem is equally effective, for they spin a web of silken threads over the slippery scales, and thus secure the necessary foothold.

All the carnivorous forms so far mentioned, though they live in marshy places, are land plants, more or less perfectly adapted for the capture of insects and other small terrestrial animals. Some of them, however, have aquatic relatives, which are to be found floating in ditches and ponds, where they prey chiefly upon small crustaceans, such as water-fleas, mussel-shrimps, and copepods, though the larvæ of gnats and other insects are also among their victims, besides which they catch large numbers of the minute motile plants known as Diatoms. The floating habit conduces to success in this matter, for small crustaceans, &c., are

PITCHER PLANTS (*Nepenthes*)

The plate represents a typical species (*Nepenthes destillatoria*) of a group of pitcher plants which ranges from Madagascar through south and south-east Asia to the East Indies, Philippines, and tropical Australia. They live in damp forest-regions, at the side of pools, in the shallow water of which their seeds germinate. The leaves are modified in a remarkable manner for the purpose of catching and digesting flying insects. The attached end of the leaf-stalk is broadened into a green expansion, followed by a tendril-like section, while the end of the stalk swells into a pitcher, which is overhung by a lid representing the blade of the leaf. Insects are attracted by the bright colours of the pitchers, and the nectar which is abundantly secreted around their openings and on the under side of their lids. But the inner side of the pitcher is as slippery as ice, and any insect that steps upon it quickly slides down into the contained fluid, which partly consists of a powerful digestive juice that reduces to solution the nutritious parts of the victim. The peptonized insect extract thus prepared is absorbed by the lining of the pitcher, and constitutes a highly nutritious and stimulating food.

PITCHER-PLANTS (NEPENTHES DESTILLATORIA) AT THE EDGE OF A TROPICAL POOL

most abundant at or near the surface. Among these aquatic carnivores are certain small cousins (species of *Aldrovandia*) of Venus' Fly-Trap, which are specialized in much the same way. They are native to South and Central Europe, India, and Australia.

The Bladderworts (species of *Utricularia*, fig. 1067) are widely-distributed ditch-plants, closely related to the Butterworts, and

Fig 1067 —Bladderworts (*Utricularia*)

represented in the British flora. They feed in part upon small aquatic organisms, and catch their prey in little bladder-like traps formed by modification of parts of the feathery leaves (fig. 1068). Each of these snares is not unlike a large water-flea in shape, and the resemblance is greatly increased by the presence of two branching bristles at the free end. Here, too, is placed the small opening into the bladder, guarded by a little transparent flap serving as a door, which opens inwards with the greatest ease, but prevents exit. Why little creatures should be attracted to

these traps is by no means clear, but minute crustaceans, &c., are fond of prying into holes and corners in search of food, while some of them may make use of the two branching bristles as a place of refuge from their enemies. And as the two bristles act as guides to the mouth of the trap the result is often tragic. Slimy hairs grow in this dangerous neighbourhood, which possibly have attractions to offer, while the little transparent door

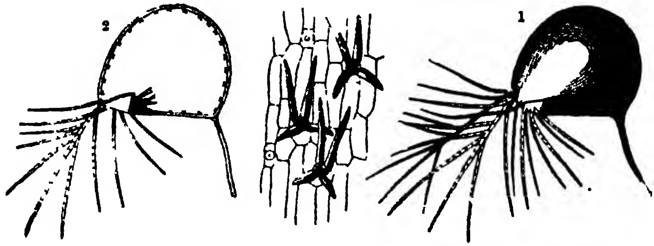


Fig. 1068.—Traps of Bladderwort (*Utricularia*), enlarged. 1, External view; 2, Longitudinal section. 3, Three absorptive branched hairs from interior. 1 and 2, × 4; 3, × 2.

must look like a spot of light, and perhaps acts as a lure. It is at any rate certain that victims are numerous, and their decomposed remains are absorbed by curious branched hairs which line the trap. The prey is apparently not digested as in Sundews and Butterworts.

The remaining topics dealt with in this chapter also more or less involve questions of nutrition, but are placed under separate headings for the sake of clearness.

ASSOCIATION OF PLANTS AND ANIMALS AS MESSMATES, MUTUALISTS, AND PARASITES

COMMENSALISM.—Two associated organisms are known as Messmates or Commensals when they live together to the benefit of one or both; the union, however, not being of so intimate a nature as to be essential to the life of either. The term commensalism was coined to express such relations as existing between different animals, but there appears to be no reason why its meaning should not be extended to cover cases where two plants, or a plant and an animal, are similarly related. As an instance of the former we may take those tropical Orchids which regularly live upon trees, and are on that account said to be Epiphytes (Gk

epi, upon; *phyton*, a plant). The advantage to the Orchids is obvious, though they do not absorb the sap of the plants upon which they live. These last, however, apparently derive no benefit from this one-sided arrangement.

There are numerous cases of commensalism between plants and animals in which the latter alone are benefited. In one of the Liverworts (*Frullania dilatata*, fig. 1069) which grow on tree-trunks there are little cup-like outgrowths on the under sides of the leaves, serving as the abodes of a species of Wheel-Animalcule (*Callidina symbiotica*). Marine plants often bear animals as messmates, which do them no harm. On a kind of brown sea-weed (*Fucus serratus*), for example, are frequently to be seen the little spiral tubes of a sort of Annelid (*Spirorbis*), which no doubt secures an increased supply of nutriment and dissolved oxygen by being moved about in the water when the tide is up. The Australian Sea-Horse (*Phyllopteryx eques*) also benefits by its association with the sea-weeds to which it bears a resemblance (see vol. ii, p. 206).

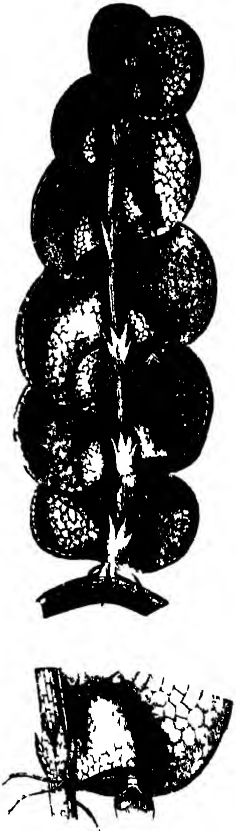


Fig. 1069.—Piece of a Liverwort (*Frullania dilatata*), showing cups in which a Rotifer (*Callidina symbiotica*) lives, enlarged. The small drawing is of one cup with its Rotifer further enlarged.

Some instances are known of commensalism between a plant and an animal, in which both derive advantage from the association. Ant-plants illustrate such an arrangement (see p. 81), and so do the Sloths of South America, in which minute algæ live in the grooves of the fluted hairs. For these algæ are provided with a sheltered home, and at the same time give a greenish tint to the hairs, the Sloths being thereby rendered less conspicuous to their enemies.

Mutualism (Symbiosis).—Organisms living together as Mutualists are very intimately associated for mutual benefit. Mutualism between two plants is well illustrated by leguminous forms and the minute fungi which live in the tubercles on their roots. And every Lichen may be regarded as a joint-stock community, con-

sisting as it does of an alga and a fungus closely interwoven (fig. 1070).

Animals and plants may also be associated in an intimate way. It appears, for example, that the process of digestion in many animals is aided by certain bacteria which always live in their internal organs, as, *e.g.*, *Sarcina ventriculi* in the human stomach (fig. 1073). Bacteria of the sort are provided with a sheltered home and abundant food. Among the Animalcules (Protozoa) a well-known example is afforded by some of the Radiolaria, which always contain so-called "yellow cells", that are regarded as a kind of alga (fig. 1071). These cells are not only sheltered, but also absorb carbon dioxide, water, and salts from the fluids of the Radiolarian, which in its turn is provided with abundant free oxygen for breathing purposes, and possibly benefits in other ways. A somewhat similar association between some Sea Anemones and minute algæ has been described. It is, however, possible that "yellow cells" and "algæ" are not plants at all, but specialized parts of the Ray Animalcules and Sea Anemones themselves.

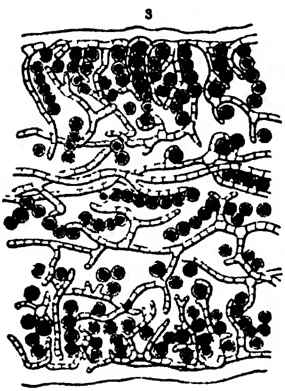


Fig. 1070.—Cross-section through a Lichen (*Collema*), showing the colourless threads of the Fungus, and the dark necklace-like filaments of the Alga ×450.

PARASITISM. An organism is known as a *parasite* when it feeds upon the substance of another organism, to the serious or fatal detriment of this unwilling "host". An *ectoparasite* lives on the outside of its host; an *endoparasite* within it.

Many plants prey upon other plants in one way or the other. Clover-Dodder (*Cuscuta*), for example, is ectoparasitic upon Clover, while various fungi live as endoparasites within higher plants, *e.g.* Potato-Fungus (*Phytophthora infestans*) within the tissues of the Potato plant.

A large number of plants are known which are endoparasitic with regard to animals. In autumn many dead flies will be seen adhering to various objects by a sort of fluffy halo which surrounds them. These have been killed by the Fly-Mould (*Empusa muscæ*, fig. 1072), the delicate threads of which branch in

all directions through their tissues. Other fungi attack various caterpillars, *e.g.* the silk-worm disease known as "muscardine" is due to the Silk-worm Mould (a species of *Cordiceps*). A number

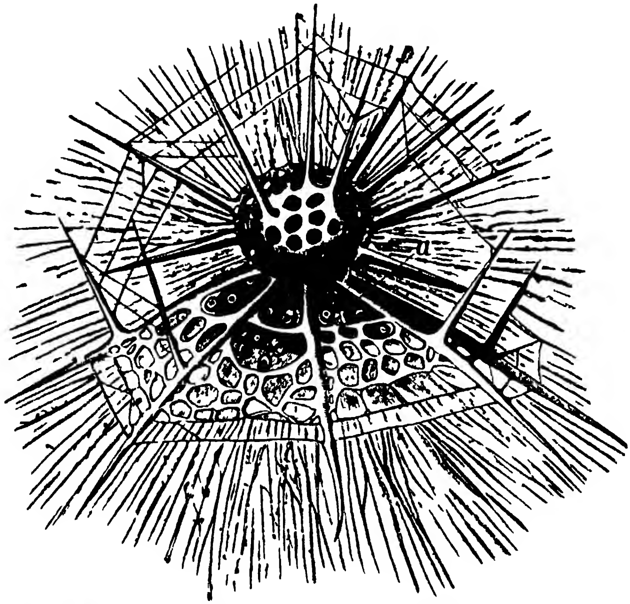


Fig 1071 —A Ray Animalcule (*Arachnocorys circumtexta*) with yellow cells (*a*), much enlarged

of skin-diseases, such as ringworm and "barbers' rash" are caused by parasitic plants of somewhat similar nature.

But the most notable, and at the same time the smallest, of the endoparasitic plants which attack animals are certain kinds of bacteria, which may literally swarm within the body, and give rise to a host of diseases, such as relapsing fever, typhoid, leprosy, Asiatic cholera, tuberculosis, diphtheria, anthrax, lock-jaw, and bubonic plague. Some idea of the small size of bacteria will be gathered from fig. 1073, or from statements that make some appeal to the imagination. It is said, for example, that 250,000,000 individuals of the species associated with bubonic plague could be crowded into the small space of a square inch. A number more than six times as great as the population of the United Kingdom at the last census.

Fig 1072 —A House-Fly (*Musca domestica*) killed by Fly-Mould (*Empusa muscæ*), enlarged

In dealing with those animals that feed upon plants it is impossible to draw any clear line between vegetarians and parasites. We shall, however, be justified in applying the latter name to a number of small forms which live, generally for part of their lives only, within the tissues of plants, one consequence being the formation of certain abnormal growths. Some of these will be dealt with later on in connection with the subject of agricultural pests. The clubbing of turnip-roots ("finger-and-toe" or

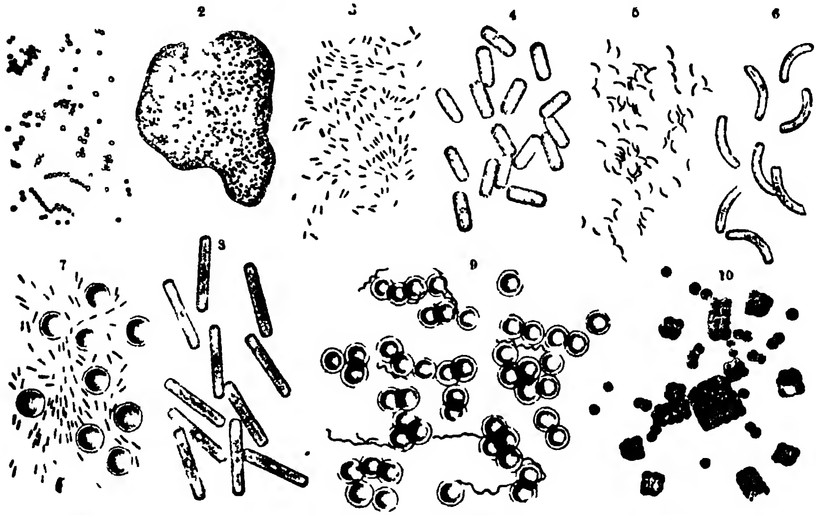


Fig 1073.—Bacteria. 1, The "blood portent" (*Micrococcus prodigiosus*); 2, gelatinous stage of the same; 3, Bacteria which produce acetic acid (*Bacterium aceti*); 4, the same on larger scale; 5, Bacteria of Asiatic cholera (*Spirochæte choleræ asiaticæ*); 6, the same on larger scale; 7, Anthrax bacilli (*Bacillus anthracis*) with red blood corpuscles; 8, the same on larger scale; 9, Bacteria of relapsing fever (*Spirochæte Obermeieri*), and red blood corpuscles; 10, Symbiotic bacteria (*Sarcina ventriculi*) from human stomach. 1, 2, 3, 5, 7, and 9, × 300; 10, × 800; 4, 6, and 8, × 2000.

"anbury"), for example, is caused by one of the Fungus-Animals (*Plasmodiophora brassicæ*), which interferes with the nutrition of the plant, causing it to grow in an unusual way. And it not infrequently happens that cereals and some other cultivated forms are attacked by small Eel-Worms, the presence of which has a stunting or distorting effect.

Most persons have noticed the curious local outgrowths known as "galls" that are common upon some plants, and tempt comparison with the tumours and cancers of animals. They are due to the attacks of Gall-Flies, small forms belonging to the order of Membrane-winged Insects (*Hymenoptera*). The female gall-

fly punctures a bud, or leaf, or stem, by means of her sharp ovipositor, and lays an egg in the incision. The injury is trifling, but sets up irritation, probably caused by some secretion, and the result is an abnormal growth. Some of the different galls to be seen on oak-leaves are represented in fig. 1074. Other examples are furnished by the familiar "oak-apples", and the "bedeguars" of rose-bushes. A particular species of gall-fly always selects the same sort of plant, and attacks the same region, the resulting gall being of definite size, shape, and colour. A remarkable case is cited below (see p. 81), where the gall benefits the plant on which it is found.

Fig. 1074.—Various Insect Galls on Leaf of Oak (*Quercus*)

Defences of Plants and Animals against One Another.—A good deal of space has already been devoted (vol. ii, p. 275) to the innumerable devices by which various animals are more or less protected in reference to carnivorous forms; but animals are also liable to be attacked by plants, especially by microscopic but deadly bacteria that induce many sorts of disease, particularly those of infectious or contagious nature. One important function of the white or colourless corpuscles which live in lymph or blood appears to be to repel the attacks of dangerous "germs" of the sort (see vol. iii, p. 4). The principle involved in vaccination or inoculation is related to the fact that animals which have been purposely subjected to the influence of a disease-germ that has been weakened by artificial methods (or to the action of a related but less dangerous kind of germ), are thereby rendered able to resist more or less successfully the onslaughts of the same sort of germ in its more virulent form. Another important application of preventive (and curative) medicine has resulted from the discovery that some animals are protected from particular disease-germs by means of complex substances (defensive proteids or anti-toxins) contained in their blood. The best-known example is afforded by diphtheria, which can be warded off, or combated if con-

tracted, by means of an anti-toxin extracted from the blood of the horse.

Turning to the other side of the question, we find that numerous plants are protected by various means against vegetarian animals. Many species, for example, more or less successfully ward off the attacks of browsing forms by mechanical devices. Of this nature are the thorns, spines, prickles, and stinging hairs with which painful experience has made most of us more or less familiar. Good illustrative cases are such common forms as gorse, blackthorn, holly, thistle, and stinging-nettle. This is not, however, the only use of sharp-pointed outgrowths, for not a few forms, *e.g.* the bramble, are "hook-climbers". It is particularly noticeable that ripening fruits are often mechanically guarded, the prickly husks of horse-chestnut being a case in point.

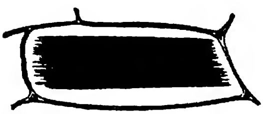


Fig. 1075.—Cell from Leaf of Virginia Creeper (*Ampelopsis*), containing a bundle of needle-crystals (raphides) of oxalate of lime, highly magnified

Quite a number of herbaceous plants contain in their soft tissues bundles of exceedingly sharp needle-like crystals (raphides, fig. 1075) which protect them against the ravages of slugs and snails, as experiment has shown. Many such crystals are to be found, for example, in the leaf-stalks of the Arum-"Lily" (*Richardia Æthiopica*).

Many plants are protected by chemical means, *i.e.* by the formation within their tissues of substances which are poisonous or nauseous, or otherwise detrimental to the well-being of would-be consumers. Forms such as Foxglove, Aconite, Monkshood, Hemlock, and Yew no doubt ward off to a great extent the attacks of browsing animals in this way. Fruits and seeds are often thus protected, and may be either simply nauseous (especially when unripe) or else contain active poisons, as in the case of the seeds of Laburnum and *Strychnos nux-vomica.* The attacks of both large and small animals are checked in many cases by means of a sticky fluid known as *latex*, which flows from an injured part, and when fresh has a milky appearance. Common examples among British plants are the Spurges (*Euphorbia*), Poppy, Greater Celandine, and Dandelion. This secretion hardens when dry, and forms a protective coat over the wound. Some tropical trees produce a kind of latex which, in the solidified condition, is known to us as india-rubber. It is almost

certainly to be regarded as a means of defence against wood-boring insects, especially beetles. The many varieties of resin and gum are also of protective nature.

We have already had occasion to note (vol. ii, p. 301) that quite a number of animals advertise their disagreeable properties by conspicuous colours or by other means. Such warning coloration also appears to be present in certain plants, as, for instance, in some of the poisonous toad-stools, which are of glaring and repulsive appearance. And here also it would seem that, as among animals, cases of Mimicry are to be found, for some harmless toad-stools closely resemble their poisonous brethren, and thus gain some amount of protection. The highly desirable *Boletus edulis*, for example, is very liable to be mistaken for its virulently poisonous cousin (*B. Satanas*).

Fig. 1076.—Acacia (*A. sphærocephala*), possessing hollow thorns in which ants finds shelter, and pear-shaped food-bodies on tips of leaflets.

Another set of plants contain aromatic or fragrant essential oils which, though pleasant enough to our own sense of smell, act as deterrents to many animals. Such are sage, mint, lavender, and many spice-producing forms.

There is still another means of defence, and one which is more interesting from the zoological standpoint than those so far described. Certain forms are known which may appropriately be termed ant-loving (*myrmecophilous*), because they maintain a "police-force" of ants, by which they are protected from leaf-cutting insects and other unwelcome visitors. The services of these hirelings are secured by means of material benefits of substantial character. A well-known case is that of a sort of Acacia (*Acacia sphærocephala*, fig. 1076), which bears little pear-shaped "food-bodies" to appease the appetites of its retainers, and also hollow thorns which furnish them with shelter. Another curious instance is afforded by a kind of Oak (*Quercus pubescens*) in which a gall-

fly (*Cynips argentea*) lays her eggs. The abnormal growths or "galls" which result from this process secrete nectar that serves to attract ants, and thus a body-guard is secured by which the attacks of caterpillars and snails are repelled. The following account is given by Kerner (in *The Natural History of Plants*) of the way in which ants protect the flower-heads (capitula) of certain Composites.—"A similar state of affairs is met with on

Fig 1077—A Saw Wort (*Serratula lycopifolia*) defended by Ants (*Formica exsecta*) against the attacks of a Beetle (*Oxythyrea funesta*)

the capitula of several Composites indigenous to South-eastern Europe, *e.g.* *Centaurea alpina* and *Ruthenica*, *Jurinea mollis*, and *Serratula lycopifolia*, the last of which is here figured [fig. 1077]. The young heads of these Composites are particularly liable to the attacks of voracious beetles, especially of *Oxythyrea funesta*, which bites big holes in them, destroying crowded flower-buds and involucral scales [*i.e.* the overlapping scales which surround the head] without the least difficulty. To meet this danger a garrison of warlike ants is employed. Honey is secreted from

big stomata [*i.e.* pores in the epidermis] on the overlapping scales of the still-closed heads in such quantities that one can see a drop of it on every scale in the early morning, whilst later in the day, as the water evaporates, little masses, or even crystals, of sugar are to be found. This sugar, either in its liquid or solid form, is very palatable to the ants, which habitually resort to these heads during the period of its secretion. And to preserve it for themselves they resent any invasion from outside. If one of the aforementioned beetles appears they assume a menacing attitude. They hold on to the involucral scales with their last pair of legs and present their fore-legs, abdomen, and powerful jaws to the enemy, as shown in the figure. Thus they remain till the beetle withdraws, if necessary hastening its retreat by squirting formic acid in its direction. Then they quietly begin to feed on the honey again."

Much has yet to be learnt about the relations between British plants and insects in the present connection, and no undoubted case of ant-guards has so far been described. Some of our native trees, however, harbour mites that appear to discharge defensive duties. Scott Elliot (in *Nature Studies*) thus speaks of them:—"Almost any common tree, such as the Lime, Ash, Elm, or Horse-Chestnut, will show on the lower side of the leaves little hairy patches which occupy the forks of the veins. If these are examined in summer with a strong magnifying glass, and stirred up with a pin, very small active . . . mites will be found. They run about quickly, and once seen, can be observed with ease, whenever looked for. The hairy grottoes which they inhabit are often rather neatly formed; but they are difficult to describe. As a rule the colour of the mite is that of the hairs amongst which it lives. These mites come forth at night, and appear to live upon bacteria and upon the spores of fungi, lichens, or algæ. But here again it is not possible to give as exact details as would be desirable." The arrangement described is of special interest, as it appears to be a case of animals defending a plant against other plants lower in the scale.

THE POLLINATION OF FLOWERS BY ANIMALS.—Of all the numerous kinds of relation between plants and animals none has attracted more attention than the one now to be briefly described. So much is this the case that, though of absorbing interest, it is almost in danger of becoming hackneyed. But

its study has done much towards revolutionizing the old cut-and-dried method of studying botany, and has caused so many persons to pay some attention to the world of life, that no excuse is made for presenting here a few facts which will be familiar to most readers, especially as the scheme of this work would be incomplete without them.

To understand the meaning of the word "pollination" it is first of all necessary to say something about the structure of flowers. These are concerned with the production of seeds, in each of which is to be found an embryo or plantlet in a dormant state, capable, under favourable conditions, of growing into a new plant. We have elsewhere seen (see vol. iii, p. 335) that in animals the first stage in propagation by means of eggs consists in the fertilization of an egg-cell or ovum by fusion with it of a smaller cell or sperm, the fertilized egg-cell afterwards developing into an embryo. The embryo in a seed has also arisen from an egg-cell, which has been fertilized by material formed in the same flower (self-fertilization) or in some other flower (cross-fertilization). The result in the latter case is better than in the former, since cross-fertilized egg-cells develop into more vigorous embryos, and many floral arrangements are to be explained as means by which cross-fertilization is brought about.

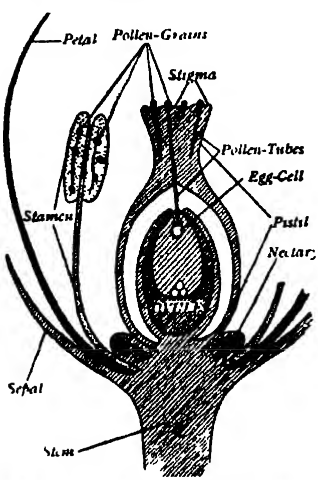


Fig. 1078.—Diagrammatic Section through a Simple Flower

Examination of a typical flower (fig. 1078) shows that it is made up of four sets of structures, all of which are specialized leaves. Beginning at the outside they are as follows:—(1) *Calyx*, consisting of a circlet of *sepals*, which may be green (as in a Buttercup), or brightly coloured (as in a Tulip); (2) *Corolla*, made up of *petals*, which are commonly conspicuous; (3) Thread-like *Stamens*, within the thickened ends (*anthers*) of which is formed the powdery substance, *pollen*, from which the fertilizing living substance is derived; (4) *Pistil*, consisting of one or more *Carpels*, which in the latter case may be either separate or fused together (a single carpel is shown in the figure). The carpels contain a varying

number of small bodies known as *Ovules*, destined to become seeds, and the most important part of an ovule is a minute *egg-cell* or *ovum*. On the top of the pistil is a rough and sticky surface, the *Stigma*.

Pollination is a necessary preliminary to fertilization, and consists of the transfer of ripe pollen-grains to the stigma. Supposing this to have been effected, a thread-like *pollen-tube* grows from each grain into the cavity of the carpel until it reaches that part of the ovule where the egg-cell is located. A nucleus-containing fragment of protoplasm (equivalent to a sperm) from the tip of the tube is then transferred to this cell, with which it fuses. The egg-cell, thus fertilized, develops into an embryo, and the rest of the ovule undergoes certain modifications, the total product being a seed.

A stigma may be pollinated by grains developed in the stamens of its own flower (self-pollination), or by grains derived from other flowers (cross-pollination). The latter, since it is followed by cross-fertilization, is the more desirable event, and the actual transfer of pollen from flower to flower is effected by water, wind, or animals, according to the nature of the arrangements which have been evolved. We are here only concerned with animal-pollinated (zoophilous) flowers, and in the large majority of these the agents are insects. Many of the characters of insect-pollinated (entomophilous) flowers have been evolved with reference to the attraction and reception of suitable guests. It was at one time the general belief that the varied odours and hues of flowers came into existence simply and solely for the delectation of mankind; as a matter of fact their significance is utilitarian, and has reference to the needs of plants themselves. For scent and colour are the means employed to attract insects (and sometimes other animals) capable of doing the work of cross-pollination. It is fortunate that the odours generally commend themselves to us, but this is not always so, for certain flowers (*e.g.* some Arums) smell like carrion, the object being to attract those flies which revel in putridity. As to colour there is of course a great variety, and some tints appeal to special visitors. Typical "bee flowers", for example, are commonly reddish-purple, purple, or blue. Other forms depend upon dusk-loving insects, especially moths, for their cross-pollination, and these are white or pale in hue, which gives them the best chance of being seen (fig. 1079).

Such flowers open in the evening, and are then most fragrant. Conspicuousness is often increased by numerous flowers being associated together.

For the entertainment of their insect-guests flowers may provide sweet sap, or produce a great excess of pollen, a highly nutritious substance, or secrete nectar. In highly-specialized forms at least the last sort of food is generally the most important, and is usually produced deep down in the recesses of the flower, often in long spur-like tubes, where it is only accessible to long-tongued insects, such as bees and butterflies.

Fig. 1079. The Nottingham Catch-Fly (*Silene nutans*) by Night: a flower being visited by a moth (*Dianthæcia albimacula*): the remains of dead creeping insects are seen adhering to the viscid stem

Flowers not only attract guests and provide refreshment, but their whole structure is often modified, it may be in a very complex way, to secure the benefits of cross-pollination, *i.e.* to ensure that pollen which is brought is deposited on the stigma by arriving guests, and make certain that departing guests take with them a fresh supply of the same material.

In many cases the adaptations existing between flower and insect are so perfect as to leave no room for doubt that each has influenced the evolution of the other. Some of the adjustments that have come into existence will best be understood by reference to concrete examples, the first two of which will be taken from the remarkable Orchis Family, the members of this being notable for the great variety of arrangements which they display in relation to insect-pollination. In one large and handsome species (*Phalænopsis Schilleriana*, fig. 1080) the attraction of colour is provided by five spreading leaves, equivalent to sepals and petals, of which the most remarkable (the *labellum*) is one which hangs down from the centre of the flower. It begins in a narrow stalk, but soon

broadens into three lobes, of which one curves up on each side, while the third takes a downward course and divides at its end into a couple of curved projections. Just at the place where the stalk expands into lobes a small double projection arises from its upper side, and this serves as a footstool for flies, which are here

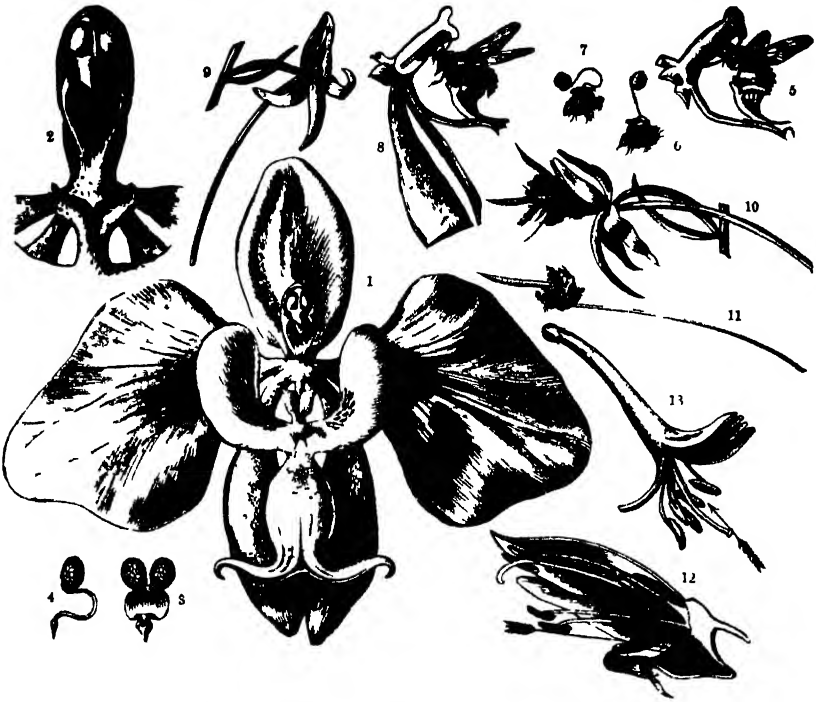


Fig. 180.—Cross-Pollinated Flowers. 1, Front view of a fly-pollinated orchid (*Phalaenopsis schilleriana*); 2, column of same showing bilobed footstool; 3, pollen masses of same attached to a sticky heart-shaped gland; 4, side view of pollen masses; 5, side view showing a fly on the footstool; 6, head of the fly with attached pollen masses; 7, the same after the pollen masses have bent forwards; 8, in vertical section, shows a fly introducing pollen masses into another flower; 9, Flower of the moth-pollinated Lesser Butterfly Orchis (*Habenaria bifolia*); 10, the same, with head of a moth (*Sphinx pinastri*) probing the long spur with its proboscis; 11, head and extended proboscis of the moth; 12, Side view of a bird-pollinated flower (*Melianthus major*) with outer part removed: four stamens and the long curved style are seen, the arrow indicates the way to the honey-containing spur; 13, Flower of a moth-pollinated honeysuckle (*Lonicera etrusca*) with long honey-containing tube: the arrow shows how to reach this the rounded stigma and stamens must be successively touched. 2, 3, 4, 6, and 7 slightly enlarged; the other figures natural size.

the invited guests. In the middle of the flower, just behind the footstool, may be seen a short projecting "column", the rounded top of which is constituted by a short stamen, immediately beneath this being a deep hollow, the stigma. The pollen is aggregated into two masses (*pollinia*), attached to a little curved plate, which

passes below into a heart-shaped sticky knob (*rostellum*) that projects into the cavity of the stigma. If now a fly alights on the footstool and begins to lick up the nectar from the stigma, its head will come into contact with the rostellum, and on leaving the flower it will carry away the pollinia, which very quickly bend forwards. When the fly visits another flower and thrusts its head into the stigma, the sticky surface of this will catch and retain the pollinia, another pair of which will become attached to the head of the insect, to be carried on in their turn to another blossom.

The Lesser Butterfly Orchis (*Habenaria bifolia*, fig. 1080) is a much smaller form native to Britain, and cross-pollinated by Hawk-Moths. A number of whitish very fragrant flowers are borne upon a long upright stalk, and there is here no platform for the arriving guests, as these sip nectar without having to alight. The nectar is contained in a slender spur, the length of which corresponds to that of the unrolled proboscis of the moth. As before, the departing guest carries away the two pollinia, which then bend downwards, and converge together into the exact position necessary to ensure their striking the stigma of the next flower visited. In regard to these movements, and the somewhat different ones made by the pollinia of other species, Darwin remarks (in *Fertilization of Orchids*):—"A poet might imagine that whilst the pollinia were borne through the air from flower to flower, adhering to an insect's body, they voluntarily and eagerly placed themselves in that exact position, in which alone they could hope to gain their wish and perpetuate their race". To this same book of Darwin's are referred those readers who desire further particulars regarding Orchids in the present connection.

The different species of Honeysuckle (*Lonicera*, fig. 1080) are also "moth-flowers", and exhibit three of the leading features just detailed for the Butterfly Orchis, *i.e.* absence of an alighting platform, pale colour, and marked fragrance. But, as in most flowers except Orchids, the pollen is dust-like, and not aggregated into pollinia.

Insects are not the only animals by which cross-pollination is brought about, for in some instances this work appears to be discharged by Snails and Slugs, Birds, or Mammals. In our two native species of Golden Saxifrage (*Chrysosplenium*), snails and slugs are said to be the agents. These plants live in damp places, and possess groups of small greenish-yellow flowers, over which

the slimy visitors crawl, transferring the pollen from one blossom to another.

The Humming-Birds of America, and the little Sun-Birds of Africa, which resemble them in appearance, suck nectar while on the wing from certain flowers. Regarding bird-pollinated forms, Scott-Elliot, who made a special study of the subject in South Africa, speaks as follows (in *Nature Studies*):—"Many tropical flowers, such as the Banana, or the beautiful *Lobelia cardinalis*, are visited by the Sun-Birds and Humming-Birds. A great proportion of these flowers have a scarlet colour, and a curved tube which exactly fits the head and beak of the bird. Others, which are visited by these beautiful and lively creatures, have the flowers massed together in large cup-shaped heads, such as the *Proteas*, or Sugarbush of South Africa. The bird stands on the edge of this cup and plunges its beak into the mass of honey flowers which fills it. There are no bird flowers in the British Flora, at least so far as the writer's knowledge goes; but sparrows can be seen to dip their beaks into the heads of the Ragwort, after insects, and it is very likely that the flower-haunting habits of the Sun-Birds began in this way." One of the bird-pollinated African forms (*Melianthus major*) is represented in fig. 1080.

Few observations have been made upon cross-pollination by mammals, but some tropical Bats are supposed to further the transference of pollen, and Kerner suggests that the same kind office is discharged by Kangaroos for Dryandra bushes. The flowers in the latter case are at a suitable height above the ground, and are arranged round the edge of a sort of cup, into which a fluid resembling sour milk trickles down from them. It is not improbable that the little Long-Snouted Phalanger (*Tarsipes rostratus*, see vol. ii, p. 181) transports the pollen of the flowers which it constantly visits.

Prevention of Self-Pollination.—The various arrangements related to cross-pollination have been so evolved that they also, at least for some time, prevent self-pollination. It may be that a particular flower contains stamens only or a pistil only, and these distinct staminate and pistillate flowers may either be on the same plant (*e.g.* Spurges,—*Euphorbia*) or on different plants (*e.g.* Willows,—*Salix*). And even where stamens and pistil are present in the same flower the pollen is commonly produced before the stigma is mature, or, more rarely, the stigma is first ready. Of other

kinds of arrangement we may take the common wild Monkey-Musk (*Mimulus luteus*, fig. 1081) as an interesting example. An insect visiting this flower first touches the bilobed stigma, which receives any pollen that the visitor may bring. But the stigma is very sensitive to contact, and immediately closes, almost like a book, remaining in this state for some time. Hence it does not receive from its own flower any of the pollen with which the departing guest has been loaded.

It ought, however, to be stated that some flowers are regularly self pollinated, while others exemplify a number of most ingenious devices for effecting this as a last resort. The whole structure of

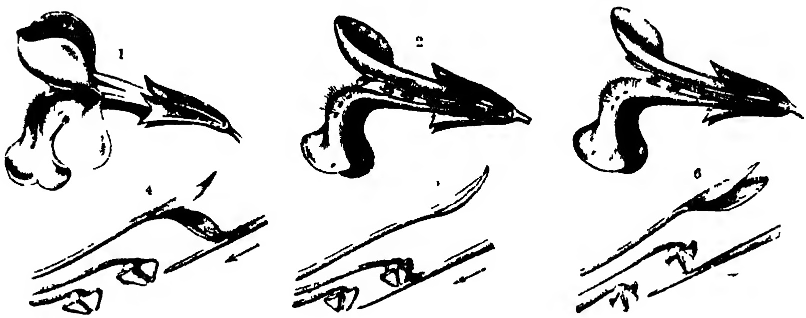


Fig. 1081.—Pollination of Monkey-Musk (*Mi*[illegible]) [illegible] longitudinal section with [illegible] with [illegible] [illegible] in the direction of the arrow [illegible] closed [illegible] and becomes covered with pollen [illegible] with[drawn] [illegible] but does not deposit pollen on the stigma as this is closed [illegible], and 3 natural size [illegible], and [illegible] somewhat enlarged.

a Foxglove flower, for example, is wonderfully adapted to cross-pollination by humble-bees, but after a time the purple corolla falls off, and in so doing drags the stamens attached to it over the stigma, so that this is self-pollinated, and if it has not already received foreign pollen, the egg-cells will be self-fertilized. Full details of this sort of arrangement will be found in Kerner and other botanical works, but would be out of place here. It is perhaps desirable to add that some authorities believe the importance of cross-pollination to have been somewhat exaggerated.

Defences of Flowers against Unbidden Guests.—The animals which are most serviceable as agents of cross-pollination are those capable of carrying pollen from one plant to another, though interchange between flowers on the same plant is beneficial to a lesser degree, and is often the chief kind of crossing which takes place in cases where a considerable number of small flowers

are crowded together. The most specialized plants lay themselves out, so to speak, to attract insects with well-marked powers of flight, or in some cases birds, and it may be mammals. These are the "bidden guests". But there are also "unbidden guests" with a liking for nectar, especially wingless insects, such as ants. In many cases these undesirable visitors simply rob the flowers without conferring any benefit. There are also numerous snails and slugs which eat up flowers altogether if they get the chance. It is for all reasons desirable that these useless and dangerous visitors should be kept away. Ogle, in the preface to his translation of a work by Kerner (*Unbidden Guests*), thus presents the matter:—
"Now Nature, who at first sight often appears a prodigal, is always found, on closer examination, to be the most rigid of economists. If no insects are to be allured, she gives . . . no nectar; she cuts off the bright petals and suppresses the attractive odours. Nor even when a bait is wanted will she give it one minute sooner than is necessary. The brilliancy, the scent, and the nectar are only furnished when the flower is ready for its guests and requires their presence; just as a thrifty housewife lights her candles when the first guest is at the door. The mature bud is furnished with no such attractions. Still more, even when the flower is mature, when its pollen is ready for transference or its stigma for pollination, when all the allurements are consequently displayed and insects invited to the feast, she still shows her economy. Guests might come who were not of sufficient importance, and the banquet be wasted on them; for it is only when insects have a certain shape, size, or weight that she requires their visits, and can use them profitably for her purposes. She requires, moreover, that they should make their entrance by the main portal, which she has specially adapted to suit their and her requirements. All insignificant and unremunerative visitors, all such, moreover, as would creep in by the back entrance, must be kept out. . . ."

It will be convenient to first describe the chief ways by which wingless insects are kept away from the flowers. One rather curious device is found in some of the Balsams, *e.g.* in a species native to the Himalayan region (*Impatiens tricornis*) which has been carefully studied. Here, as in many other plants, there are little expansions (stipules) at the bases of the leaves, where they join the stem. Of each pair of stipules one is transformed into a nectar-secreting gland (nectary) in the form of a thick curved plate,

so situated that insects creeping up the stem are sure to find it. As soon as the Balsam begins to open its flowers nectar is abundantly secreted by these nectaries, and being both abundant and more accessible than that in the flowers, unwelcome guests are diverted from these. Regarding this sweet fluid and its use Kerner makes the following remarks:—"The honey-loving ants lick it up eagerly, and are content not to stray farther upwards. Actual observation shows that the flowers of *Impatiens tricornis* are free from ants, whilst these stipular nectaries are much frequented by them. Their presence in the flowers is very undesirable, since they could readily get at the honey there without touching the pollen or stigma. And more than this, they would not only pilfer the honey, but they would also drive away those winged insects for which the honey is prepared the welcome guests that pollinate the flowers. We are justified on the facts in regarding this diversion of the unbidden guests as an indirect protection of the floral honey."

Fig 1082.—A Teasel (*Dipsacus laciniatus*), showing water cups formed by fusion of bases of leaves

Insects are not infrequently prevented from reaching the flowers by means of a watery barrier. This is obviously so in the case of water-lilies and other aquatic plants, and may also be observed in some land forms. In Teasels, for example, the leaves are arranged in pairs, the bases of each pair being united together to form a sort of cup, in which water collects, so as completely to surround the stem (fig. 1082).

Slippery surfaces are often present, on which creeping insects can find no foothold. There is sometimes a smooth coating of wax, as in certain Willows, where the catkin-bearing twigs are thus protected. Another interesting case is that of the Snowdrop

(*Galanthus nivalis*, fig. 1083). Here the smooth flower-stalk is bent over, so that the flower hangs down, and a creeping insect trying to reach it is almost certain to fall when it reaches the sharp bend. The nectar secreted in the green grooves of the petals is intended for flying insects. If one of these approaches from below it will first touch the stigma, effecting pollination if it has previously visited another snowdrop. And in getting the nectar it is sure to jolt the stamens, causing a shower of pollen to fall on its back, ready for transfer to other blossoms.

Fig 1083.—Flower of Snowdrop (*Galanthus nivalis*)

A more drastic method of dealing with creeping insects is found in many plants which exude a sticky fluid, especially in the neighbourhood of the flowers, or actually upon them. Sometimes this is of the nature of latex, as in the Lettuce (*Lactuca sativa*), where the flower-heads are surrounded by overlapping scales from which the milky secretion readily escapes, quickly coagulating into a sticky mass that catches and smothers ants and the like. The flower-stalks of Catch-Flies (see p. 86) and various other forms are covered by a glutinous layer, to which the bodies of trespassers are often found adhering. But more commonly the secretion is poured out by variously-situated glandular hairs. In Plumbago, for instance (fig. 1084), they are borne on the calyx. It would appear that in some instances the captured insects are used as food, after the fashion of the carnivorous plants already described (see p. 68).

Fig 1084.—Flower of ***Plumbago Europæa*** (enlarged), showing glandular hairs on the calyx

So far we have dealt with the exclusion of wingless insects, but in the case of large flowers evolved in relation to bees, wasps, butterflies, &c., small-winged insects are equally undesirable visitors, since they steal nectar without effecting cross-pollination. Such forms are altogether excluded, or else made effective by arrangements in the flowers, which Kerner thus describes in general terms (in *The Natural History of Plants*):—"Peculiar folds and cushions, walls and gratings,

brushes and thickets of hairs are present, guarding the entrance and rendering access difficult, whilst still allowing it. Large and powerful animals find these obstacles no hindrance, and readily brush them aside; small ones, however, cannot do this, but have to climb over or circumvent the obstacles. And in many cases this enforced divergence by small insects from the direct path brings about the desired result. For, in circumventing these folds and barricades and hairs, they are unconsciously led past the anthers and stigmas, contact with which is unavoidable. Thus, what would otherwise be useless visitants become welcome guests. They are conducted indirectly to the honey by these curious structures, which may, in a sense, be termed 'path-finders'." Cursory examination of such flowers as Foxglove or Pansy will show the presence of barricades of the kind mentioned (see also fig. 1085). Path-finders for the guidance of invited guests are often present in the form of conspicuous colour-streaks, which converge towards the source of nectar. Pansy, Azalea, and Pelargonium are particularly good examples of this.

Fig 1085—Section through Flower of a Honeysuckle (*Lonicera alpigena*), showing protective tufts of hair enlarged

The defences and other arrangements which have been evolved in various connections by plants and animals are never completely successful, and with changed surroundings are apt to fail. This applies not only to "mice and men", but also to flowers. Kerner states, for example, that the flowers of some 300 European plants are systematically robbed by humble-bees, which take a short cut to the nectar by biting through the calyx or corolla. The result may be disastrous, for in some of these plants but few seeds are produced, so that they are becoming rare, and in course of time will probably die out altogether. Certain Alpine Catch-Flies (*Silene Pumilio* and *S. Elizabethæ*) are in this evil case. Kerner suggests that such plants date back to a time when there were no, or but few, humble-bees in the region where they now grow, and that they have since failed to evolve means of defence against the new kind of attack.

Wingless enemies of soft-bodied character, especially snails

and slugs, are not kept off by smooth surfaces or sticky secretions. But such creatures are easily baffled by prickles, bristles, thorns, and other sharp structures, and these are often found in the neighbourhood of the flowers.

Dispersal of Plants by Animals.—Since the large majority of plants are fixed, means of dispersal are clearly a necessity, as otherwise they would have to struggle for existence with their own offspring. And it is only when numerous individuals of a species are placed in favourable surroundings that the species has any chance of escaping extinction. It is not therefore surprising to find that there are almost innumerable ways by which dispersal is effected. Sometimes the plant itself is the agent, sending out creeping stems above or below ground, or ejecting its fruits, seeds, or spores to a distance by explosive or elastic mechanisms. Currents of air and water are also of great importance in this connection. But we are here only concerned with the chief ways in which animals are pressed into the service of plants for this purpose, or it may be render assistance of more casual kind.

Many of the small plants which float in ponds, such as Duckweeds (*Lemna*) and various algæ, must often cling to the legs of water-birds, and get carried bodily from place to place. And it is noticeable that the buds of somewhat larger aquatic plants, such as Frog-bit and Bladderwort (*Hydrocharis* and *Utricularia*), possess a slimy covering by means of which they readily adhere to the plumage of such birds. Among marine plants a curious means of transit is exemplified by various sea-weeds which certain crabs plant on their backs to make themselves inconspicuous (see vol. ii, p. 287). On the decease of such a crab his little "garden" goes on growing, unless perchance he has been swallowed whole by some predaceous form.

A good many land-plants propagate by means of "offshoots", *i.e.* specialized branches, &c., which grow into new individuals, and cases have been noted where animals assist in the dispersal of such offshoots. Some of the rounded Mexican Cacti (species of *Mammillaria*), for example, produce little spherical shoots studded with barbed bristles, and which are very readily detached from the parent plant. They readily cling to the coats of various mammals and may thus be carried for a considerable distance.

Dispersal of Seeds and Fruits by Animals.—As already explained (p. 85), a seed may be regarded as a matured ovule,

in which is contained a dormant plantlet, that has resulted from the fertilization of an egg-cell. The fertilizing process stimulates the growth of various parts external to the ovules, leading to the production of what may broadly be called a "fruit", which for our present purpose may be considered as a seed-carrier. A cherry or plum, for example, is a fruit, within which is a single seed—the "stone". A long account of the different kinds of fruit would be out of place here, but it may be well to add that many are hard and dry, *e.g.* hazel-nuts (of which the "kernels" are the seeds), poppy-"heads", and the so-called "seeds" of Sunflower or Carrot.

The dispersal of seeds in many plants results from the fact that a considerable number of animals are fruit-eaters. And in such cases the seeds being protected by hard coats often escape digestion. It would appear that the attractive colours and palatable qualities of numerous fruits have been evolved with direct reference to this. While still unripe such fruits are inconspicuous and more or less nauseous, but become extremely conspicuous by the time they are ready for consumption, thus advertising their desirable properties as articles of diet. Though monkeys and other fruit eating mammals no doubt largely assist in plant dispersal, birds seem to play a more important part in the matter. Kerner made a large number of experiments which tend to prove this. He found, for example, that the hard-coated seeds of stone-fruits and berries passed quite uninjured through the bodies of ravens and jackdaws; also that the blackbird, song-thrush, rock-thrush, and robin, which eagerly devour fleshy fruits, throw up the seeds if these are large, as in Barberry and Privet. The fate of small seeds swallowed by the last four birds is thus described by him (in *The Natural History of Plants*):—"Of the fruits and seeds which passed through the intestine of one or other of these birds, 75 per cent germinated in the case of the blackbird, 85 per cent in the case of the thrush, 88 per cent in the case of the rock-thrush, and 80 per cent in the case of the robin. . . . From these experiments it is evident that the dispersal of edible fruits through the agency of thrushes and blackbirds is not, as was formerly supposed, an exceptional phenomenon obtaining in the mistletoe only, but one that may take place in the case of many other plants, and other observations prove that, as a matter of fact, it does take place."

Some animals store up seeds and fruit for future use, and as for various reasons many of these escape being eaten, the storing habit undoubtedly promotes dispersal. Squirrels, jays, and many ants may be cited in illustration. The case of ants is peculiarly interesting. According to Kerner's observations the seeds which prove attractive to these little creatures are those which, although smooth, possess a little rough outgrowth technically known as a "caruncle", as in Violet, Greater Celandine, Snowdrop, Periwinkle, and some Spurges. It is only this caruncle which is eaten, the rest of the seed being left untouched, and capable of germination.

Besides the seeds and fruits which specially appeal to the appetites of animals, there are many others which become attached to their bodies, and are thus effectively dispersed. This may take place without any special adaptations to clinging, as in the case of the floating seeds of many aquatic plants, which adhere to the plumage of birds, or where moist earth containing seeds sticks to the feet of birds or other animals.

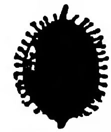


Fig. 1086.—Fruit of *Linnæa borealis* (×5) studded with glandular hairs

There are, however, a large number of fruits and seeds which are either sticky or else studded with hooks, their chances of transport by animals being thus greatly increased. Stickiness results in many cases from exposure to moisture, as in the seeds of Meadow Saffron (*Colchicum*) which have often been observed adhering to the feet of sheep, cattle, and horses. A somewhat more specialized case is afforded by fruits which owe their viscidity to the presence of glandular outgrowths, *e.g.* *Linnæa borealis* (fig. 1086).

A firmer means of attachment is found in seeds and fruits provided with hooks, and its efficiency would seem to be proved by the fact that about ten per cent of Flowering Plants are provided with such arrangements. They have apparently been evolved, at least in many cases, in relation to the hairy coats of Mammals, for they are particularly characteristic of plants of low stature, with which such animals are likely to come into contact. Many examples are found among the members of our native flora, as everyone who knows the country must have observed. The little globular fruits of the Goosegrass or Cleavers (*Galium aparine*, fig. 1087) are studded with little recurved bristles which prove very effective holdfasts, and the "burrs"

of Burdock (*Arctium majus*, fig. 1088) cling with great tenacity to sheep and other animals. Each burr consists of a number of fruits enclosed by a great many narrow scales, each one of which is bent into a hook at its tip. A different but equally effective arrangement is present in Avens (*Geum urbanum*, fig. 1088). The group of fruits is not surrounded by clinging scales, but each is provided with a long hook. In some foreign fruits the hold-fasts are of formidable character, and cause much pain to the unfortunate animals which unwillingly promote dispersal. A well-known instance is that of the Harpoon-Plant (*Harpagophytum*) of South Africa, the large fruits of which are covered with stout radiating projections provided with powerful hooks. They are the source of much inconvenience to such animals as antelopes and lions, being said to sometimes cause the death of the latter.

Fig 1087.—Fruits of Goose-Grass (*Galium aparine*) covered with Hooks, a few of the hooks, magnified, are shown below

Dispersal of Spores by Animals.—Fleshy fungi are eaten by various insects that swallow vast numbers of the minute spores by which such plants propagate, these passing uninjured through their bodies. In some cases flies are attracted by a sweet fluid (as in Ergot, *Claviceps purpurea*), or by evil-smelling moisture that exudes on the spore-producing surface (as in the Stinkhorn, *Phallus impudicus*). Earth-Worms and other burrowing forms no doubt help to disperse the spores of underground fungi, such as truffles. The last-named plants are also eagerly sought and devoured by pigs, with similar results. The dissemination by animals of disease-producing bacteria is too notorious to require emphasizing.

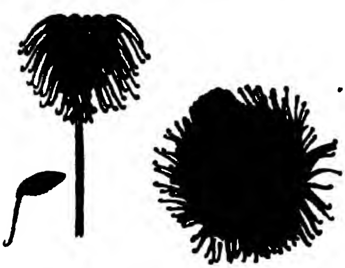


Fig. 1088.—Group of Hooked Fruits of Avens (*Geum urbanum*) is shown to left, with a single fruit on larger scale. On the right is shown a group of the Fruits of Burdock (*Arctium majus*) surrounded by hooked scales.

CHAPTER LXI

ASSOCIATION OF ANIMALS—COLONIES

Having considered the chief sorts of relation which exist between animals and plants, we have now to deal with the association of individual animals, whether of the same or different species. In the sections on Food and Defences (volume ii) one kind of connection has been treated at considerable length, *i.e.* that which links carnivorous (and to some extent omnivorous) forms with their prey, and we have seen that the bodily structure of both attackers and attacked have been more or less perfectly adapted to the exigencies of attack and defence. Another chapter of the same story will engage our attention rather later on, when Animal Parasites receive consideration, but it will be convenient in the meantime to enter into some particulars regarding other kinds of relation.

Animals of the same species may be associated together in three chief ways, conveniently described under the headings of Colonial Animals, Social Animals, and Courtship and Mating of Animals.

COLONIAL ANIMALS

Colonial Animalcules (Protozoa).—The minute and lowly creatures known as Animalcules are distinguished from animals higher in the scale by the fact that they are single cells or units of structure, *i.e.* they are unicellular. They propagate, as a rule, by splitting (fission) or budding (gemmation), and in a number of species the new individuals which thus come into existence remain connected together, forming a *colony* (fig. 1089). The members of such a colony are usually all alike, each of them performing all the duties of life for itself, and species for which this is true have therefore been described as "physiologically unicellular". Most of them are fixed, as, for instance, in Epistylis

(fig. 1089), which is closely allied to the common Bell Animalcule (*Vorticella*), a non-colonial form And another colonial form (*Codosiga*), represented in the same figure, also has solitary relatives In cases where a number of units are associated together it is clearly advantageous that there should be a "division of labour" on similar principles to those which have increased

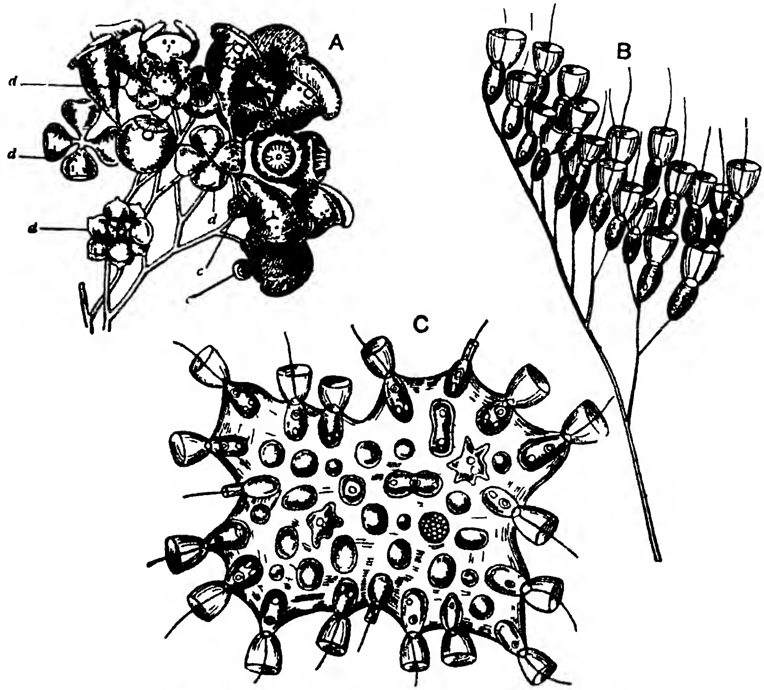


Fig 1089—Colonial Animalcules, enlarged to various scales A, *Epistylis* c, c small individuals conjugating with large ones d d, d, d individuals undergoing fission B *Codosiga* C, *Proterospongia*

the output and improved the quality of manufactured articles. There are certain colonial Animalcules which exhibit an early stage in division of "physiological" labour. Of this an excellent example has already been given (see vol. iii, p. 333) in Volvox, where some members of the colony become specialized in connection with propagation by means of eggs As another instance we may take Proterospongia (fig. 1089), which consists of numerous individuals imbedded in a gelatinous substance. Some of these are charged with the duty of securing food for the colony, and the projecting end of each such individual is surrounded by a

"collar" from the centre of which springs a thread (flagellum) which executes lashing movements. Within the jelly are other amœba-like individuals, which divide actively, some of the products of division serving to increase the size of the colony, while others are probably liberated to found fresh communities. Proterospongia is of special interest, as it suggests the way in which Sponges have possibly been evolved from simpler animals, for it is characteristic of Sponges that the spaces within their bodies should be more or less lined with "collar cells" that strikingly resemble the collar-provided individuals of the colonial Animalcule just described.

All forms higher in the scale than the Protozoa are collectively known as Many-celled Animals or Metazoa. In any one of these, *e.g.* a Zoophyte, a Worm, or a Mollusc, the body is a more or less complex community of cells, exemplifying in various degree the principle of division of physiological labour, with accompanying specialization. And there can be little doubt that these cell-communities have been gradually evolved from colonial Protozoa. This view has been discussed to some extent in an earlier section (see vol. iii, p. 333).

COLONIAL SPONGES (PORIFERA).—In this group of animals the colonial condition is the rule, a colony being produced by the budding or incomplete fission of an original individual. Sometimes the members of a community are fairly distinct (see vol. iii, p. 343), but in other cases it is difficult or even impossible to say where one ends and others begin. The absence of sharp boundary-lines between adjacent individuals is well exemplified by a very common British species, the Crumb-of-bread Sponge (*Halichondria panicea*), which may be seen as an encrustation of light-brown colour on rocks near low-tide mark.

COLONIAL ZOOPHYTES (CŒLENTERATA).—Vegetative propagation by means of budding or fission is very characteristic of members of this large group, and the buds or fission-products commonly remain united together to form colonies, of which the members are usually clearly marked off from one another. They are united together by what may be termed a "common flesh" (cœnosarc), and their digestive cavities all communicate with a more or less complex system of canals by which this is traversed. It therefore follows that food taken in and digested by one individual may benefit other members of the same community, a

fact which has had much to do with the course of evolution in certain species. Reference should be made to vol. i, pp. 474–481, where some of the Colonial Zoophytes are figured and described, and also to vol. iii, pp. 327–328, for a brief account of the life-histories of such colonies. We are here only concerned with the characteristic features of colonial life, and it will be convenient to consider separately the two sub-groups of Sea-Flowers (*Anthozoa*) and Hydroids (*Hydrozoa*).

Colonial Sea-Flowers (*Anthozoa or Actinozoa*).—To students of the British fauna the most familiar Sea-Flowers are the solitary forms known as Sea-Anemones, which abound on our shores. But in warmer parts of the globe Corals are equally abundant, and these may be either solitary or colonial. The former, or cup-corals, may be compared to anemones, but the lower part of the body is supported by a limy skeleton, while the latter may be regarded as colonies of cup-corals, and present wide variations in shape, according to the mode of growth. In the majority of cases the members of the colony are all alike (fig. 1090), but this is not invariably the case. For in some of the Eight-rayed Sea-Flowers (*Octactinia*), *e.g.* the Sea-Pen (*Pennatula*), some of them are devoid of tentacles, and participate neither in active feeding nor in the production of egg-cells. Their special duty appears to be that of promoting breathing by setting up currents of sea-water which circulate through the fleshy substance of the colony. Ciliary action is the agency employed.

Fig. 1090.—Small Colony of a Coral (*Astroides calycularis*)

Hydroids (*Hydrozoa*).—The branching or encrusting colonies known as Hydroid Zoophytes exemplify division of labour more or less. As we have elsewhere seen, some of the individuals are specially concerned with egg-propagation, and these may be liberated as little free-swimming jelly-fish or medusæ (see vol. iii,

p 350) This, however, is not the only possibility, as will be seen by reference to fig 1091, which represents a small part of a species of hydroid (*Aglaophenia*) In addition to the ordinary members of the colony, each provided with mouth and tentacles there are two kinds of small mouthless individuals One of these is in the form of a slender thread which can be stretched out to some little distance and is possessed of a thickened sticky tip It acts as a food catcher ensnaring small animals to be swallowed and digested by its larger fellows for the benefit of the community The other kind of mouthless individual is somewhat stouter and richly provided at its free end with batteries of stinging-cells capable of dealing effectively with larger prey or warding off the attacks of enemies When these fighting individuals are called into action the other members of the colony can be withdrawn into the little cups that surround their bases, being thus out of harm's way

Fig 1091 Small part of a Colony of *Aglaophenia* [illegible] large [illegible] Ordinary individual [illegible] food catchers between [illegible] other [illegible] fighting [illegible] cavity of colony *f* outer layer of body [illegible] investment

An extreme case of division of labour is presented by the free swimming colonies of Hydroids known as Compound Jelly Fish (Siphonophora) which have probably been evolved from simple medusæ by a process of budding (see vol 1, p 481) The shape of the colony depends upon the way in which this process has been effected Sometimes the buds have arisen from the "umbrella" of the original medusa or they may have grown from the walls of the mouth-bearing 'handle' The chief kinds of individual that have been thus produced are represented diagrammatically in fig 1092 The umbrella of the original medusa loses its function as a swimming organ and becomes a float, while (in the case represented) the handle, of which part only is shown, carries a variety of members which contribute in various ways to the common weal of the community Some are swimming bells which, by alternately opening and closing, effect propulsion through the water Others

are transformed into fishing-lines that catch food, and at the same time are so well provided with stinging-cells as to effectively keep off enemies. There are also digestive individuals, which devour and digest the animals caught by the fishing-lines. Some members are reduced to tentacles, ministering to the sense of touch (and possibly smell); others again are in the form of protective plates, covering and sheltering adjacent individuals. And there are also egg-producing members of the colony which may be liberated as little medusæ, thus promoting dispersal. In different species there are considerable variations in detail, and the actual arrangements in one case (*Stephalia corona*) are shown in fig. 1093.

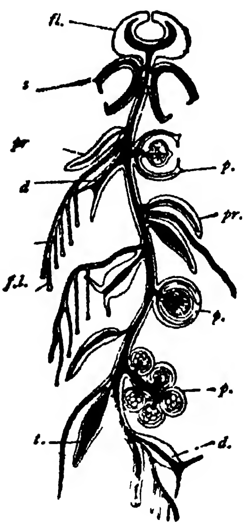


Fig. 1092.—Diagram of various individuals in a colony of Compound Jelly-Fish (*Siphonophora*), central cavity of colony indicated in black. *fl*, Float; *s*, swimming bell; *d*, *d*, digestive individuals; *fl*, branched fishing line; *pr*, protective individual; *p*, *p*, *p*, various forms of propagative individual; *t*, tentacle.

Colonial Moss-Polypes (Polyzoa).—With a single exception the members of this group produce colonies by budding, after the fashion of Hydroid Zoophytes, for which they are sometimes mistaken, though in reality much higher in the scale. Some

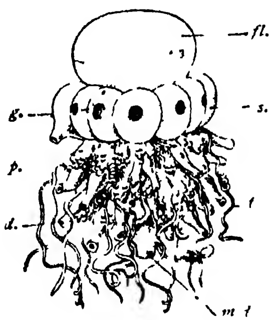


Fig. 1093.—A Compound Jelly-Fish (*Stephalia corona*), reduced. *fl*, Float; *s*, swimming bell; [illegible], conducting individual; *d*, small digestive individual; [illegible], large central digestive individual; *t*, tentacle; *p*, group of small propagative individuals.

of the members of such a colony may be greatly specialized for various purposes (fig. 1094), *e.g.* they may be modified into rounded receptacles (ovicells) in which the eggs develop till the time of hatching. In certain species there are bird's-head individuals, which execute vigorous snapping movements, the object of which is extremely doubtful. Cleanliness is possibly promoted, or perhaps the attacks of small parasitic forms may thus be warded off. It has also been noticed that the powerful jaws often succeed in catching little worms, crustaceans, &c., apparently holding them tenaciously till they die and decompose. The suggestion has been made that the decayed fragments of these victims are carried by

ciliary action into the mouths of the unmodified members of the colony, thus serving as food. But there is no definite proof that such is the case. Individual Moss-Polypes may also undergo still greater modification into whip-like threads that actively lash about in all directions. Cleanliness and defence have here again been suggested as the ends to be served, and cases have been observed where the action is so vigorous as to move the entire colony about. That the surrounding water should be thoroughly stirred up is probably advantageous with reference both to feeding and breathing. The only thing, however, that we definitely know about these curious structures is, that they have been evolved from bird's-head individuals by suppression of the "head", and prolongation of the "lower jaw" into a slender filament.

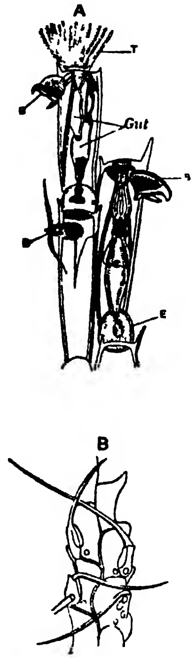


Fig. 1094.—Parts of Colonies of Moss Polypes, enlarged. A, *Bugula*, B, B, B, bird's head individuals, one holding a small worm; E, ovicell; T, tentacles of an ordinary individual. B, *Scrupocellaria*, showing three whip-shaped individuals.

Colonial Tunicates (Urochorda).—The formation of colonies is clearly related to powers of increase by means of budding or fission, and consequently all the members of certain animal groups devoid of such powers, *e.g.* Arthropods and Molluscs, are non-colonial. This is also true for the vast majority of Backboned Animals, the most notable exception being afforded by many species of the lowly and degenerate forms known as Sea-Squirts, Tunicates, or Ascidians. Most of these are fixed to some firm object when adult, and their sedentary life has no doubt had much to do with the degeneration they have undergone (see vol. iii, p. 421). A good many Tunicates are non-colonial or "solitary", but others bud to produce colonies of various shape. In such species the individual members may be borne on a creeping stem and clearly marked off from one another, much as in a hydroid zoophyte, or the association may be much more intimate. In the latter case the individuals are sunk within a sort of common body (like the cœnosarc of colonial corals), and there is a continuous protective investment or common test. A good instance is afforded by Botryllus (fig. 1095), to be found at low tide on our coasts as a sort of bluish encrustation on sea-weeds and stones. It

presents at regular intervals a number of flower-like markings, each of which is made up of a circlet of individuals, with their mouths near the tips of the "petals". A small hole in the centre of the flower leads out of a cavity ("common cloaca") into which are discharged the waste products of the members of the group. The surface population of the sea is also partly made up of colonial Tunicates. The Salps, for instance, present two stages in their life-history, one of which propagates by budding, the other by eggs (see vol. iii, p. 422). A large number of the latter stage are connected together when young into "chains", which may be regarded as temporary colonies. These ultimately break up into their constituent members. A notable example of a permanent free-swimming Tunicate colony is afforded by the Fire-Cylinder (*Pyrosoma*, fig. 1095), abundant in the Mediterranean and elsewhere, and giving off a bright phosphorescent light, possibly as a means of protection. The colony is shaped like a hollow cylinder which, in one large species (*Pyrosoma gigantea*), may be as much as 5 feet long, and possesses a contracted aperture at one end, the other being closed. The external surface is covered with pointed projections of the firm test. The small but very numerous individuals are imbedded transversely in the wall of the cylinder, their mouths being external. The large central cavity receives all the products of waste, and is comparable to the common cloaca of a Botryllus circlet. The size of the colony is augmented by budding, and eggs are also produced, which develop into minute colonies that are liberated into the surrounding water, there to grow to their full size.

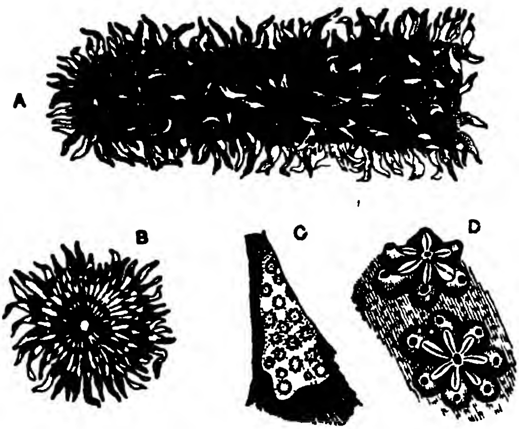


Fig 1095.—A, Fire Cylinder (*Pyrosoma*) in side view, the small rounded areas are the mouths of members of the colony B, Open end of same C, Small colony of *Botryllus*, showing circlets of individuals. D, Two circlets, enlarged

CHAPTER LXII

ASSOCIATION OF ORGANISMS—SOCIAL BACKBONELESS ANIMALS (INVERTEBRATA).

Many animals are social or gregarious, and in such cases division of labour between the members of a community is more or less perfectly exemplified. The mere fact that many individuals of the same species live together in the same place does not entitle them to be termed social, in the sense here intended, unless there is some sort of co-operation which benefits the animals living together. It would hardly be justifiable, for example, to describe oysters, cockles, or star-fishes, as colonial animals. But even here the species may be benefited, *e.g.* weakly individuals are weeded out in the keen struggle for existence, so that the stock becomes increasingly healthy and strong. And from such casual kinds of association communities of very complex kind have gradually been evolved, the benefits to be derived from division of labour between individuals giving various species a greatly improved chance of survival in the competition with other species. But here a qualification must be made. For in the world of organisms, by the irony of fate, an extreme penalty attaches to elaborate specialization resulting from adjustment to the exigencies of a certain set of conditions. The surroundings of animals (and plants) are constantly changing, and if these alter suddenly, as they are liable to do, a well adapted species may be unable to adjust itself with sufficient rapidity to the new order of things, and hence be doomed to extinction, while simpler but more plastic forms may survive. Many lowly organisms have endured through countless ages, while others of more complex kind have quickly succumbed to rapid alterations of their environment at a time when their continued dominance seemed most certain. Innumerable instances of this far-reaching principle are to be drawn from the geological record, which preserves for us the past history of the globe.

The most interesting cases of the social habit are to be found among Insects and Backboned Animals, which it will be well to consider separately.

SOCIAL INSECTS (INSECTA)

Some of the most remarkable facts in natural history have been made known by those who have studied the complex communities existing among various species of Membrane-Winged Insects (Hymenoptera) and Net-winged Insects (Neuroptera). The extent to which division of labour is carried varies greatly in different cases, so that we are able to get some notion of the successive stages which have marked the evolution of the social habit.

SOCIAL MEMBRANE-WINGED INSECTS (HYMENOPTERA).—The most salient point distinguishing highly organized communities of Bees, Wasps, and Ants is the presence of a varying number of "castes" or kinds of individual. In the Honey-Bee (*Apis mellifica*), for instance, a hive contains not only males (drones) and an egg-producing female (queen), but also numerous "workers", which are a second kind of female, having nothing to do with the production of eggs, but, as their name indicates, labouring for the benefit of the republic. And in other cases there may be more than three castes as we shall see in the sequel. Worker honey-bees differ markedly in size and structure from the queen, as the result of a long course of evolution, and it will be desirable to begin with simpler communities, where such sharp distinctions do not exist.

BEES.—Some account has already been given of Carpenter-Bees, Mason-Bees, and Leaf-cutting Bees, solitary forms in which the female not only lays eggs but also makes and stores a nest (see vol. iii, p. 390). These and many other non-colonial insects exhibit very elaborate adaptations to their surroundings, and it would be a mistake to consider them as necessarily lower in the scale than colonial forms, which have evolved on entirely different lines. Here, as in all other cases, success in the struggle for existence may be attained in widely different ways.

From the purely solitary life led by the bees above-mentioned, we pass to a curious case described by Fabre (from his observations in South France), where a certain amount of co-operation is

associated with a large amount of independence. The case is that of certain rather small "short-tongued" bees (species of *Halictus*), which are represented in the British fauna. There are here no workers, but by the united labours of a number of females a branching underground passage is dug out at night, there being a single opening to the exterior, and close to this an enlargement or "hall" for the greater convenience of individuals wishing to pass one another. Within this underground home each female makes her own particular nest, consisting of ovoid waterproof cells, and attends to her domestic duties after the fashion of solitary species. A sentinel is said to be posted at the common opening of the burrow, so that some understanding would seem to be arrived at in the matter of mounting and relieving guard. But, apart from this, the individuals living together have no more social organization than the different families occupying a dwelling made up of a set of "flats", who use a common stair and the same street door. If the said families had constructed these by their joint efforts the analogy would be more complete.

The last example is a sort of side-branch in social evolution; for a comparatively simple case in the direct series of adaptations we may turn to the large insects familiarly known as Humble-Bees (species of *Bombus*), which are well represented in our own country, and live above or under the ground in communities which endure for a single year only. They exemplify the beginning of the caste-system, for in addition to males there are three varieties of the opposite sex, *i.e.* queens, small females, and workers, which in appearance and structure resemble one another pretty closely. We do not find the same marked differences that exist between the queen and worker in honey-bees, while the power of egg-laying is not restricted to the queen, though she is the mother of most of the members of the community. The habits of several species have been closely observed, and the succession of events is somewhat as follows. A queen which has survived the winter begins her work as foundress of a society when the spring is well advanced, and food in the form of nectar and pollen is abundant. Selecting a sheltered spot, on the surface or below the ground according to the species, she successively constructs two or three large waxen cells, the material for which is derived (as in social bees generally) from a number of small glands that open on the under side of her abdomen: a

proportion of pollen being added. When a cell is of full size it is lined with a mixture of pollen and honey, several eggs are laid in it, and a roof is put on. After several days' rest the next cell is made, and stocked in the same way. About the time that the second cell is completed duties of another kind are added to the tale of work. For, meanwhile, the eggs first laid have hatched out, and the bee-grubs, having exhausted their scanty store of provisions, require feeding. To do this their mother bites a hole in the enclosing cell, and supplies honey from her mouth as required. Here, and in other cases, the "honey" is not the same thing as the "nectar" found in flowers. A bee swallows the latter, taking it into a crop or "honey-bag", into which the gullet dilates. Within this receptacle it undergoes a kind of fermentation by which it is converted into honey. So far the life-history is much like that of a solitary form, all the work being done by the mother. But in the next stage division of labour begins to play an important part. The full-fed grubs spin silken cocoons, and pass into the quiescent or pupa stage, from which they emerge as "workers". By gnawing away the wax the queen assists their escape from the enclosing cell. As workers become numerous they justify their name by undertaking the labours of building and storing, ultimately enabling the queen to devote herself entirely to egg-laying. For each egg a separate cell is constructed. As the community increases in size small females may be produced, and towards autumn larger "drone cells" are made, and still larger "queen cells". It is stated that these are not stored with food, the corresponding grubs being from the first assiduously nursed by the workers. By the time that drones and queens are mature the community has attained its full size, and may consist of from 300 to 400 individuals, under favourable circumstances. The pairing of the young queens in the course of a nuptial flight constitutes the climax of the year's drama, for as winter approaches the temporary community becomes disintegrated. All the workers and drones perish, together with many of the queens, but some of the latter live through the winter in a torpid state to found fresh societies the following spring. It should be added to this account that when the community is in full working order special unclosed cells are made, to be stored with honey or pollen for general use. These "honey tubs" and "pollen tubs" serve as a larder, which

is constantly being replenished during fine weather, to be drawn upon when it is wet. Old brood-cells may be enlarged for the same purpose, but are never put to their original use a second time.

For one species of Humble-Bee (*Bombus ruderatus*) a remarkable arrangement has been described. It is said that in every nest one bee is told off as a "trumpeter". This individual sounds *reveillé* at from 3 to 4 a.m., rousing her fellows to the labours of the day, and if removed is replaced by another. The habit of storing food, existing to some extent in Humble-Bees, is carried much further in the Honey-Bee (*Apis mellifica*) and its numerous relatives, and has probably had much to do with the evolution of the complex social life which these exhibit. It enables a community to live on through the unfavourable season of the year, thus becoming permanent, and this continuity has rendered possible division of labour to a greater degree, being at the same time associated with well-marked differences between the castes, so far as queen and workers are concerned. The former is of comparatively large size, and her only duty is to produce eggs, while the varied labours of the hive fall to the lot of her smaller sisters. The community is only temporary as regards the drones, none of which survive the winter, but are replaced by a fresh set which hatch out the following year. A few further details regarding the Honey-Bee will be given in a later section.

The Social Wasps (*Vespidæ*) live in communities which, so far as at present known, exist for one season only, as in Humble-Bees, to which they present a further resemblance in the fact that the workers are not markedly unlike the queen, and are more or less capable of laying eggs. The building-material, however, is not wax but a sort of paper, made by chewing woody matter and mixing it with a fluid secreted by certain glands of the mouth-region. We may take to illustrate the annual cycle one of three British species (*Vespa Germanica*, fig. 1096) in which the nest is constructed underground. The foundress queen begins work in spring, making a small number of cells in the place which is to be the top of the nest, and depositing an egg in each. The cells are neither stored nor closed. Her next task consists in feeding the grubs as they hatch out, first with honey or fruit-juice, and later with the bodies of insects, especially flies. By

means of her strong jaws she removes the hard parts of the prey, chewing up the rest into a kind of mince-meat adapted to the tender digestions of her offspring. When they have reached their full size the grubs spin cocoons and pass into the pupa stage, from which they emerge as worker wasps about four weeks after the date when the eggs were laid. Without loss of time these take over the work of building and nursing, and even feed their mother, who soon has nothing to do but lay eggs in the cells as they are constructed. The complete nest consists of a series of combs, connected by little pillars, and the building operations are carried on from above downwards Each comb is made up of a large number of roughly hexagonal cells, the mouths of which are directed downwards. Towards the end of summer cells of larger size are made, in which queens and drones are reared, but many of the latter are brought up in the ordinary small cells. After mating has taken place the community is soon broken up; most of the insects die, but some of the queens survive the winter, and found the communities of the following year. Wasps appear to be extremely sensitive to cold, and it is perhaps partly for this reason that the nest is surrounded with a covering made up of layers of paper (see fig. 1096).

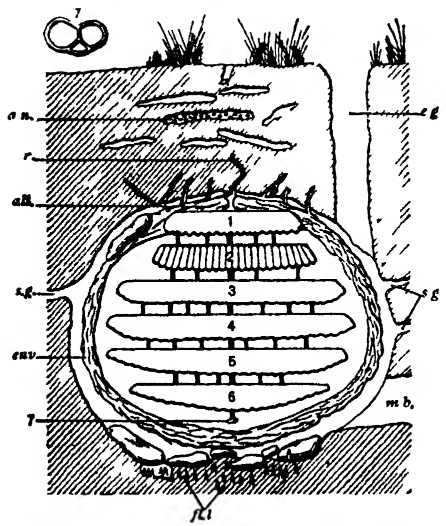


Fig 1096 — Section through Nest of a Social Wasp (*Vespa Germanica*), rather less than ¼ natural size

e.g, Entrance gallery, *s g*, side galleries 1–7, combs connected by pillars (7 above main figure shows arrangement of the three cells of the youngest comb) *env*, papery envelope of nest *r*, root to which first foundation is attached (other roots with secondary attachments also shown) *a n*, part of an ant s nest *fl*, larvæ of a fly *m b*, mole burrow

The nests of many species of social Wasp are suspended from plants, while the Hornet (*Vespa crabro*) prefers to build in a hollow tree. There is a large amount of variation as to size, shape, and durability, while in some cases earth is added to the ordinary building material.

The social habits of Ants are even more complex than those of Bees and Wasps, and some account has already been given of the way in which the members of certain species procure and store food (see vol. ii, pp. 103 and 206). There is no more fascinating department in the whole realm of natural history than the study of ant life, for these little creatures live in a wonderland which is all their own. The elaboration of some of their communities is very considerable, and the welfare of the individual is rigorously subordinated to the interests of the species. Some of the more salient points are thus ably summarized by Sharp (in *The Cambridge Natural History*):—"Observation has revealed most remarkable phenomena in the lives of these insects. Indeed, we can scarcely avoid the conclusion that they have acquired in many respects the art of living together in societies more perfectly than our own species has, and that they have anticipated us in the acquisition of some of the industries and arts that greatly facilitate social life. The lives of individual ants extend over a considerable number of years—in the case of certain species at any rate,—so that the competence of the individual may be developed to a considerable extent by exercise; and one generation may communicate to a younger one by example the arts of living by which it has itself profited. The prolonged life of ants, their existence in the perfect state at all seasons, and the highly social life they lead are facts of the greatest biological importance, and are those that we should expect to be accompanied by greater and wider competence than is usually exhibited by Insects. There can indeed be little doubt that ants are really not only the 'highest' structurally or mechanically of all insects, but also the most efficient. There is an American saying that the ant is ruler of Brazil. We must add a word of qualification; the competence of the ant is not like that of man. It is devoted to the welfare of the species rather than to that of the individual, which is, as it were, sacrificed or specialized for the benefit of the community. The distinctions between the sexes in their powers or capacities are astonishing, and those between the various forms of one sex are also great. The difference between different species is extreme; we have, in fact, the most imperfect forms of social evolution coexisting, even locally, with the most evolute. These facts render it extremely difficult for us to appreciate the ant; the limitations of efficiency displayed by the individual being in some

cases extreme, while observation seems to elicit contradictory facts. About two thousand species are already known, and it is pretty certain that the number will reach at least five thousand."

The caste-system is well-marked among Ants, and there are at least three sorts of individual, males, queens, and workers or modified females. The two former are commonly winged, and pairing usually takes place in the air. After this has been accomplished the males soon die, while the females cast, or it may be bite off, their wings, and enter upon their further duties. In some species the male alone possesses wings, while it more rarely happens that the contrary is true. Cases are also known where both kinds of male exist in the same species, the female being winged, or both kinds of female are associated with winged males. There may also be distinct castes of workers, one consisting of large individuals (workers major), and the other or others of small ones (workers minor). In many cases, too, there is a caste of "soldiers" distinguished by the great size of their mandibles. Like workers they are modified females. To all intents and purposes, indeed, the societies of Ants, like those of Bees and Wasps, are female republics. The "queen", it is true, has all her wants attended to by the workers, but does not actively direct the affairs of the community, having no special authority. The care bestowed upon her, indeed, would appear to be simply in recognition of the fact that she is necessary for the continuance of the society. In ant-societies there may be more than one queen. There appears to be no doubt that these insects are able to communicate certain kinds of information to one another. Indeed, without some power of communication there would be endless confusion in a large community. As it is, we find that foraging expeditions, warfare, and the complex economy of the nest are all carried out in an orderly fashion. In human societies even republics require some sort of government for the direction of individual efforts, but this often appears not to be the case here. The armies of our native species, for example, so far as we know, are entirely made up of rank and file, without officers and non-commissioned officers. Yet such an army often seems to conduct its campaigns strategically, and deals very effectively with tactical problems which arise after it has taken the field. How this is possible we are not yet able to say, for our own mental powers have been evolved on very different lines. There is certainly a basis of instinct, *i.e.* inherited

capability of doing certain things on impulse when appropriate occasions present themselves; but since individual ants profit largely by experience, we may also say without hesitation that many of their actions are intelligent. There can be little doubt that young workers receive a practical education in their duties, learning by example if not by precept. If so, we have a very convincing proof of marked intelligence. Where, as in some tropical ants, there are numerous castes, the mental life of the community is probably more complex, but comparatively few observations have been made on this difficult subject.

The early stages in the formation of societies have been observed in some species, and are probably substantially the same in all. A foundress queen lays her first batch of eggs, and carefully tends the larvæ when they hatch out, until they pass into the pupa stage, from which they emerge as workers, who at once concern themselves with the industrial work of the young community. The queen is therefore soon able, as in the ordinary social wasps and bees, to restrict herself solely to the duty of egg-laying. One important point in the domestic economy of all ant-societies may here be mentioned. Special cells of paper or wax are not constructed for the reception of eggs, as in Bees and Wasps, but these are deposited in chambers, variously situated, according to the species. It is further to be noted that the larva may or may not spin a cocoon before passing into the pupa state. When a cocoon is made it is removed by the workers at the proper time, so as to facilitate the escape of the perfect insect.

There is a large amount of variation as to the number of individuals contained in an ant-society. This is very large in most of the kinds which have been carefully studied, and it is naturally so in cases where the social life is very complex. Simple instances are afforded by some of the Indian Ants (species of *Polyrhachis*), where a single queen and less than a dozen workers live together in a little one-chambered dwelling that looks almost like a miniature bird's-nest, and is constructed of a papery substance with a lining of silk. These small homes are found on leaves, and are commonly so placed or made as to be inconspicuous. Another sort of Asiatic Ant (*Œcophylla smaragdina*) lives in larger communities upon foliage, of which the leaves are converted into dwellings in a very remarkable manner. The workers roll them up and fix their edges together by means of a viscid fluid derived

from the silk-glands opening near the mouths of the larvæ. A worker engaged in this task holds a larva firmly in her jaws, and holds it to the required spot, using it in fact as a living gum-bottle.

Some of the leading features in the communal life of a large society of the industrious insects under discussion may be learnt from the study of our largest native species, the reddish-coloured Wood-Ant or Horse-Ant (*Formica rufa*). It abounds in the fir-woods of our southern counties, where the large "ant-hills" which it constructs are conspicuous objects. The winged males and females are not far short of half an inch in length, and there are two kinds of worker, which are respectively about one-fourth, and from one-fifth to one-sixth of an inch long. The nest may be nearly three feet high and some eighteen feet round at its base, and is made up of fir-needles, together with all sorts of plant fragments. The vicinity of the nest is trodden down into a number of "ant-roads", which are the scene of much busy going and coming. The larger workers are principally concerned, when outside the nest, with collecting building materials, while an important duty of the smaller workers is to collect the "honey-dew" of aphides, insects which are often picturesquely described as "ant-cows". The substance in question is a sugary fluid that exudes in considerable amount from the intestines of these little creatures, and is eagerly swallowed by the workers, a great deal of it passing into their dilated crops. Having filled themselves up with this desirable food, the workers hurry back to the nest, and obligingly distribute some of their store for the benefit of the larvæ, and their adult friends who have meanwhile been engaged with the internal economy of the nest. There are no special receptacles corresponding to the honey-tubs of humble-bees or comb-cells of ordinary bees, for storage of what is not immediately needed. Indeed none of our native ants indulge in the luxury of a larder, and remain in a torpid condition during the winter. The food is by no means limited to honey-dew, but is of very mixed nature, for caterpillars, various adult insects, and miscellaneous vegetable matter all figure in the bill of fare. There is a constant return of foraging parties to the central home (fig. 1097).

The ant-hill is literally riddled with labyrinthine galleries expanding at intervals into rounded chambers, and for some depth the underlying ground is mined with passages continuous with those above. It is easier to destroy an ant-hill than to get any

clear idea of its internal economy, but J. G. Wood (in *Insects at Home*) thus describes a very ingenious device by which he was enabled to gain some knowledge of the kind —"I have, however, succeeded in obtaining an excellent view into the interior of a Wood-Ants' nest, though it was but a short one. Accompanied by my friend Mr. H. J. B. Hancock, I was visiting some remarkably fine Wood-Ants' nests near Bagshot. We took with us a large piece of plate-glass, placed it edgewise on the top of an ant-hill, and, standing one at each side, cut the nest completely in two,

Fig 1097 —Horse Ants (*Formica rufa*) collecting Food and Building Materials

leaving the glass almost wholly buried in it After the expiration of a few weeks, during which time the Ants could repair damages, we returned to the spot, and, with a spade, removed one side of the nest as far as the glass, which then served as a window through which we could look into the nest It was really a wonderful sight. The ant-hill was honey-combed into passages and cells, in all of which the inhabitants were hurriedly running about, being alarmed at the unwonted admission of light into their dwellings. In some of the chambers the pupæ were treasured, and these chambers were continually entered by Ants, which picked up the helpless pupæ and carried them to other parts of the nest where the unwelcome light had not shown itself. Unfortunately, this view lasted only a short time."

The most important and arduous duty of the workers is to look after the eggs, larvæ, and pupæ, and these are distributed through the nest with due regard to variations of moisture and temperature, since both of these affect development. The queens are carefully tended, and their eggs are carried off to suitable chambers. From time to time these are carefully licked, and it is also said that they are smeared with nutritious fluid that is absorbed by the embryos. When the larvæ hatch out they are fed with great assiduity and their toilet requirements attended to. The full-grown larvæ spin cocoons, within which they become pupæ (the so-called "ants' eggs"), which also receive unremitting attention. The workers bite away the enclosing cocoons when the perfect insects are ready to come out. Some of them are workers, others winged males and females which fly about in swarms. After mating, the large majority of the swarming individuals perish, but some of the females survive to found fresh communities, or sometimes to be taken into existing nests.

The stings of Wood-Ants are not sufficiently well developed to be of use, but their poison-bags contain formic acid, which can be squirted to a considerable distance, and is an effective defence. This particular acid, as its name indicates (L. *formica*, an ant), was first known as a product of insect-life. The strong mandibles of the workers are also weapons of no despicable character. These ants co-operate for offence and defence, and Lord Avebury (in *Ants, Bees, and Wasps*) thus describes their tactics, and those of a related species:—"*Formica rufa*, the common Horse Ant, attacks in serried masses, seldom sending out detachments, while single ants scarcely ever make individual attacks. They rarely pursue a flying foe, but give no quarter, killing as many enemies as possible, and never hesitating, with this object, to sacrifice themselves for the common good. *Formica exsecta* is a delicate, but very active, species. They also advance in serried masses, but in close quarters they bite right and left, dancing about to avoid being bitten themselves. When fighting with larger species they spring on to their backs, and then seize them by the neck or by an antenna. They also have the instinct of acting together, three or four seizing an enemy at once, and then pulling different ways, so that she on her part cannot get at any one of her foes. One of them then jumps on her back and cuts, or rather saws, off her head. In battles between this ant and the much

larger *F. pratensis*, many of the *F. exsectas* may be seen on the backs of the *F. pratensis*, sawing off their heads from behind." Such practices would be greatly deprecated in human warfare.

Some of the most remarkable features in ant-life have reference to the use they make of aphides (fig. 1098), and some species, instead of merely sallying forth to collect honey-dew, in the way described above for the Wood-Ant, have advanced to the pastoral stage of social life, and may be described as cattle-keepers. This is well illustrated by our native species of Lasius. The common little Black Garden-Ant (*Lasius niger*), which lives in elaborate underground dwellings, is particularly partial to aphides which live on twigs and leaves, moving them to convenient places for "milking" operations, and carrying their eggs into its sheltered home for the inclement winter season. The small Yellow Ant (*Lasius flavus*), another underground species, goes further than this, for Lord Avebury states that four or five distinct kinds of aphis are found in some numbers in its nest, belonging to root-feeding species. The same observer made some most interesting observations (on captive specimens) of the way in which (like *L. niger*) these ants tend another sort of aphis, which is not a root-feeder, and he gives the following summary of the facts (in *Ants, Bees, and Wasps*) —"Here are aphides, not living in the ants' nests, but outside, on the leaf-stalks of plants. The eggs are laid early in October on the food-plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, exposed to the severity of the weather and to innumerable dangers, but brought into the nests by the ants, and tended by them with the utmost care through the long winter months until the following March, when the young ones are brought out and again placed on the young shoots of the daisy This seems to me a most remarkable case of prudence Our ants may not perhaps lay up food for the winter, but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer, a case of prudence unexampled in the animal kingdom." It should be added that after carrying the young aphides to the appropriate food-plant the ants wall them in with earth, and the enclosures thus made may be almost

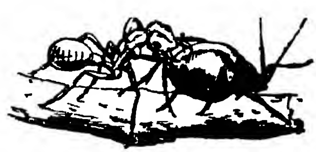


Fig 1098—Ant (*Myrmica rubra*) "Milking" an Aphis (*Aphis sambuci*)

called "cattle-pens." Some remarks will be made in a subsequent chapter on ants as slave-owners, and on the beetles, &c., which live in their nests.

The caste-system is carried to an extreme in one of the common Foraging-Ants (*Eciton hamata*, see vol. ii, p. 104) of Tropical America, a carnivorous species which possesses a powerful sting. Besides winged males and wingless females there are "soldiers" with enormous jaws, large workers, and two sizes of small worker. These ants and those of allied species have no permanent abode, but wander about from place to place after the fashion of armies. After carrying on offensive operations for some time they construct temporary quarters, where they cultivate the domestic virtues and bring up their offspring. Belt gives the following account of ants of the sort in regard to this matter (in *A Naturalist in Nicaragua*):—"They make their temporary habitations in hollow trees and sometimes underneath large fallen trunks that offer suitable hollows. A nest that I came across in the latter situation was open at one side. The ants were clustered together in a dense mass, like a great swarm of bees, hanging from the roof, but reaching to the ground below. Their innumerable long legs looked like brown threads binding together the mass, which must have been at least a cubic yard in bulk, and contained hundreds of thousands of individuals, although many columns were outside, some bringing in the pupæ of ants, others the legs and dissected bodies of various insects. I was surprised to see in this living nest tubular passages leading down to the centre of the mass, kept open, just as if it had been formed of inorganic materials. Down these holes the ants who were bringing in booty passed with their prey. I thrust a long stick down to the centre of the cluster, and brought out clinging to it many ants holding larvæ and pupæ." Ants as agriculturalists and mushroom-growers have been dealt with in an earlier section (see vol. i, p. 207).

Social Net-Winged Insects (Neuroptera).—The interesting social insects known as Termites live in complex communities somewhat resembling those of Ants, with which, under the name of "White Ants", these forms are often confounded. The resemblance, however, is very superficial, while the differences are profound. Termites are not invested in strong plate-armour, their exo-skeleton being comparatively thin, nor do they possess poison-

glands or stings. But the jaws of the individuals which do the work of the community are very powerful, as in Ants. Most species shun the light and are pale in colour (hence the name "White" Ants), and in such cases only the kings and queens possess eyes, the other castes being blind. There are, however, leaf-cutting Termites in South Africa which move about in open daylight. Eyes are here present in all castes. There is no marked metamorphosis, for the young do not hatch out of the egg as helpless grubs, but as active nymphs, which attain their full size after several moults. The number of castes varies greatly in the different species, and matters are complicated by the presence of nymphs in various stages of development. But in all cases which have been investigated the just-hatched nymphs are to all appearance alike, and it is probable that their subsequent fate depends upon the nature of the food, the matter being more or less regulated by the mature inhabitants of the nest. The same thing is, indeed, largely true for social Bees and Wasps. In the Honey-Bee, for example, the grubs destined to become queens are fed differently from their fellows.

Only the fully mature queens and kings (as the full-blown males are here usually termed) are provided with wings, both pairs being of equal size, the arrangement of veins being quite unlike that characteristic of Bees and Wasps, as might be anticipated from the fact that Termites belong to an entirely different order. Near the base of each wing there is a weak place, facilitating detachment after the first and only flight has taken place. Queens and kings swarm from the nest much as in Ants, and associate themselves in pairs. The vast majority fall a victim to insectivorous birds and other animals, but enough survive to secure the formation of fresh societies, at least in some cases. Nor do we find that speedy death is the necessary sequel to mating for a king termite, as in the case of drone bees, for a nest commonly contains, in some species at any rate, a royal couple, both of whom are carefully tended for the term of their natural lives. Of other kinds of individual, soldiers are always found and generally workers, some of both these castes being modified females and others modified males. A Termite society is not, like those of Bees and Wasps, a female republic.

The only two known species of European Termite have been carefully studied, in Sicily, by Grassi and Sandias, whose chief

results will be briefly summarized. The societies of some of the African forms are still more complicated, but here our knowledge is in many respects very incomplete, though it may prove interesting to give a few details. Rather more than 100 species of Termite have been so far described, and these are probably only a tithe of those which actually exist. They abound in the tropical and warmer temperate regions of the world.

The Yellow-Necked Termite (*Calotermes flavicollis*) of the Mediterranean littoral is of peculiar interest, for its communities are small (under 1000 individuals), and the habits are comparatively simple. The home is a hollow within a dead or decaying tree, and the architectural operations are limited to increasing the size of the hollow as may be necessary, and making partitions or the like with waste matter ejected from the intestine, saliva being employed as a cement. Within this simple home are found a king and queen, together with a number of soldiers and nymphs. There are no workers. The soldiers are distinguished, as in Termites generally, by the possession of huge heads and formidable jaws. The habits as regards food are somewhat remarkable, and promote sanitation of the nest in an unusual degree. Wood is the staple diet, but it is a substance very difficult of digestion, and the pellets which are voided from the intestine are eaten again and again, until their nutritive properties are exhausted, when they are either employed as building materials, heaped up in remote parts of the nest, or dropped outside. Partly digested food may also be ejected from the crop, suggesting the arrangement found in other social insects as regards sweet substances. The salivary secretion is also highly nutritious, and not a mere digestive juice. All the cast skins are used as food, and burial rites are simple, the bodies of deceased friends augmenting the bill of fare. The young nymphs are fed at first on saliva, from which they are promoted to material ejected from the crop and intestinal pellets, wood pure and simple being eaten more or less at a still later stage. A grim sort of fate attends the soldiers, for their huge jaws would appear to cut them off from the most abundant items in the dietary, and they are driven to cannibalism. Not only do they devour the dead, but shorten the sufferings of the sick and dying by eating them alive. It is supposed that they are in a state of permanent hunger, and

may be well excused for sometimes doing a little private slaughter among their healthy relatives, as they are said to be apt to do when excited. It is on the whole a good thing that human social life has evolved on rather different lines, in spite of the horrors of war and other matters which an intelligent Termite would deprecate.

Winged queens and kings swarm from the nest at certain seasons of the year, and any pair fortunate enough to escape the appetites of birds or other foes is capable of starting a fresh society.

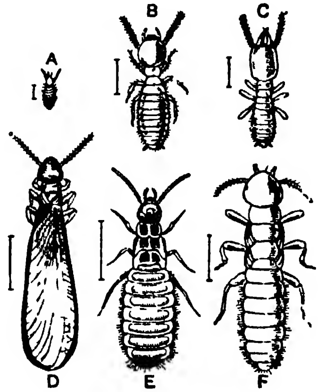


Fig. 1099.—Light-Shunning Termite (*Termes lucifugus*). A, Young larva. B, adult worker. C, soldier. D, winged adult. E and F, reserve or substitution queens. Actual sizes indicated by the vertical lines.

The Light-shunning Termite (*Termes lucifugus*) is the second and only other European species. A society consists of many thousands of individuals, and there are workers as well as soldiers. Winged queens and kings swarm from the nest as in other cases, but in Sicily these all perish, so far as yet known. It seems probable, however, that the existing societies there were founded in the first instance by royal pairs, though Grassi has never found these in any of the very numerous Sicilian nests he has examined. In France, however, the investigations of Perris and Perez show that in that country communities can be founded in the usual way. Since fresh individuals are constantly being produced in the Sicilian nests, we naturally enquire how this is possible in the absence of true queens and kings, *i.e.* termites which at one time possessed wings and were fully adult. The answer is found in the existence of remarkable castes which may be termed "substitution royalties". Here, as in other species with complex social life, the workers seem to be aware of the necessity for continued egg-production, and appear to feed some of the nymphs in such a way that they become capable of continuing their kind, though wings are not developed, and certain immature characters are retained. The substitution queens and kings are not all alike, as may be gathered to some extent from fig. 1099. Even this apology for a king is rarely found in a nest, a possible explana-

tion being that this particular species is given to regicide, though this would be contrary to the usual habit of Termites. The following table (modified from Grassi) will show the various kinds of individual that have been found in the dwellings of *Termes lucifugus*:—

- 1. Young, undifferentiated nymphs.
  - 2. Nymphs that are not to be concerned with egg-production.
    - 5. Soldier nymphs.
      - 7. Soldiers.
    - 6. Worker nymphs
      - 8. Workers.
  - 3. Nymphs that will be concerned with egg-production.
    - 9. Nymphs of the first form.
      - 12 Winged insects.
        - 14. True royalties.
      - 13 Reserve royalties (?).
    - 10. Nymphs of the second form.
      - 15. Substitution royalties.
    - 11. Reserves for royalties (present if 14, 15, and 4 are wanting, or if 15 and 4 are not sufficiently numerous).
  - 4. Reserves for royalties (present if 14, 15, and 11 are absent, or 14 and 15 not sufficiently numerous).

When we remember that the societies of this and other species may exist for a very long time, the reason for the production of substitution royalties becomes tolerably clear. We may suppose that a society is in the first instance founded by a fully-developed royal pair, after they have shed their wings. When a sufficient number of workers have been matured to do the ordinary work, the royal pair for the rest of their lives are carefully tended (though possibly in some species the king may be destroyed), being afterwards replaced by substitution royalties, devoid of wings, these being unnecessary under the circumstances. Provision would, of course, be made for a continuous succession of queens and kings of this kind, and the society would only die out when the environment became in some way very unfavourable.

The Light-shunning Termite lives in wood, like the Yellow-necked species, but its building operations are much more elaborate. Complex galleries and chambers are tunnelled out, and, as before, the exhausted intestinal pellets are employed in constructive work, the cement being saliva. The same sorts of food are used as in the other species.

The societies of certain Termites native to tropical Africa are the largest and most complex yet discovered, though our knowledge regarding them is unfortunately very incomplete. The most famous species is the Warrior Termite (*Termes bellicosus*),

which was long ago investigated by Smeathman in West Africa. His description in the *Philosophical Transactions* for 1781 is astonishingly correct, considering the date at which it was written. Each of the vastly numerous communities constructs and lives in a wonderfully solid dwelling in the form of a mound that may be as much as 20 feet high, and is shaped something like a sugar-loaf. It is chiefly made of earth glued together with saliva, while a good deal of the interior work is carried out with the materials already mentioned for other species. A single

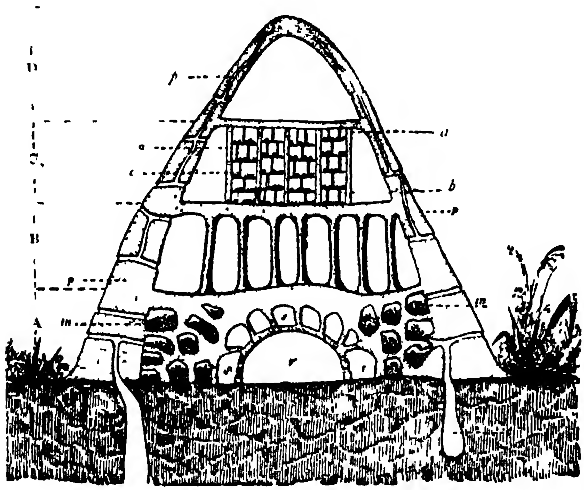


Fig. 1100.—Section through Mound of Warrior Termite (*Termes bellicosus*), greatly reduced. For description see text.

royal couple constitute the centre of social life, and there are both worker and soldier castes, the members of the former being much the larger. The name "soldier" is not altogether a happy one, for it appears that the workers fight much better, while the supposed military individuals are rather fond of looking on. Below the termite dwelling (fig. 1100) are excavations (*c*) from which earth for building is procured, while the dwelling itself is divided into four stories (A–D), surrounded by a common external wall (*p* on left), which is traversed by transverse and longitudinal galleries (*p* on right). The centre of the ground-floor (A) is occupied by the royal chamber (*r*), which is of considerable size, and enclosed by a curved wall in which there are numerous

apertures, giving free access to the workers, and furthering ventilation. The king lives here of his own free-will, while the queen is obliged to be a prisoner, for her abdomen is so filled with eggs as to be of relatively enormous size. Attendant crowds of workers are constantly to be found within the royal chamber, attending to the various wants of the king and queen, and carrying away the eggs, which are sometimes laid at the rate of 60 per minute (fig. 1101). Numerous worker-dwellings (*s*) adjoin the abode of their titular sovereigns, and the outer part of the ground-floor is

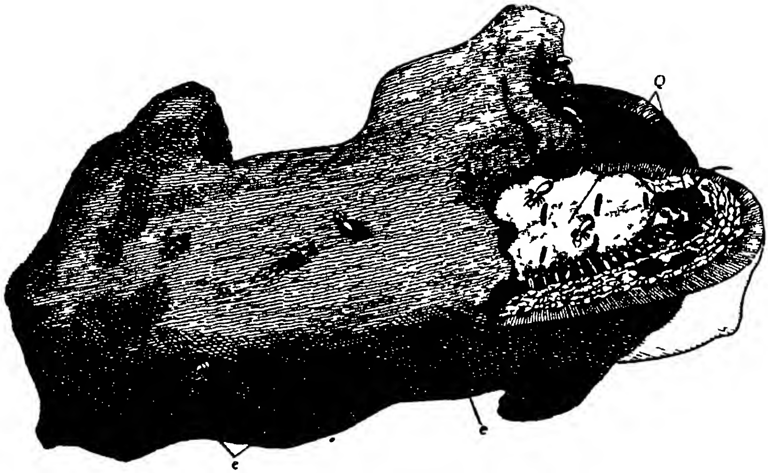


Fig 1101 —Royal Cell of Warrior Termite (*Termes bellicosus*) broken open to show queen (Q) and her attendants e (on left), Openings into royal cell e (on right), an opening that has been closed up about ⅓ natural size

occupied by numerous store-chambers (*m*) in which are heaped up gums and other dry vegetable products. The first floor (B) is a large pillared hall, which has no known use except that of serving as an air-space. The second floor (C) may be called the "nursery", for here the eggs are hatched out, and the young nymphs carefully tended. The space is subdivided by means of strong vertical partitions (*a*), and the central portion is marked off into a large number of small compartments (*b*), separated from one another by more delicate party-walls (*c*). The third story or attic is simply an air-space. It will be noted that the arrangements are such as to further the maintenance of equable conditions as regards temperature and moisture, to variations in which Termites appear to be particularly sensitive.

In concluding this chapter it may be noted that the larvæ of many insects are found feeding together in "companies", which have hatched out from batches of eggs laid at the same time and place. Probably the most remarkable case of associated larvæ is afforded by the maggots of certain of the little two-winged flies known as Fungus Gnats (*Mycetophilidæ*). One of these is familiar as the "Army Worm" (*Sciara militaris*) of Europe, and allied forms are native to the United States. The maggots live among rotting leaves, and are sometimes found moving from place to place, united together by sticky threads, and writhing along like a snake. The largest armies of this sort may include millions of individuals, and are stated to reach an extreme length of 100 feet, with a breadth of 6 inches, and a depth of 1 inch. The migrations are probably dependent on the question of food-supply.

CHAPTER LXIII

ASSOCIATION OF ORGANISMS—SOCIAL BACKBONED ANIMALS (VERTEBRATA)

That many backboned animals are of gregarious habit is too well known to require emphasis. Our vocabulary includes many words signifying communities of animals, *e.g.* we speak of a "shoal" of fishes, a "flock" of birds, a "pack" of wolves, a "herd" of antelopes, and so on. The societies of which the existence is implied by many such words exhibit a type of communal life differing greatly from that described for insects, and one that is in some respects less interesting, except in so far as it throws light on the problems of sociology, with which all intelligent persons are more or less concerned. The complex conditions resulting from numerous individuals living together have not here led to profound anatomical specialization, as they have in the case of such insects as ants.

SOCIAL FISHES (PISCES).—That so many Fishes should be associated together in shoals would seem to be dependent in many instances on the place and manner of spawning. In ordinary bony fishes (Teleostei) the eggs are nearly always fertilized externally, and it is obvious that this process is facilitated when numerous individuals seek the same locality for the purpose. The Herring (*Clupea harengus*), fig. 1102), for example, approaches our shores in order to deposit its eggs in shallow water, where they adhere to various objects; the Salmon (*Salmo salar*) ascends rivers for the same purpose; and the Common Eel (*Anguilla vulgaris*) migrates in vast numbers to the deep sea in order to spawn. How far the movements of migratory fish involve division of labour is not at present known. It is not impossible that some of the older individuals may act as "leaders", though this is little more than a conjecture.

The gregarious habit of many predaceous fishes, such as Sharks, Dog-fishes and Mackerel, may conduce to success in

procuring prey, and certainly gives an opportunity for co-operation to the benefit of the community. On the other hand, living in shoals must tend very greatly to increase mortality among ill-defended species, which thus are bound to attract the notice of their foes. The well-being of the individual is here, as generally, subordinated to the interests of the species, the matter apparently being determined by the exigencies of spawning.

Though some of the AMPHIBIANS and REPTILES may be more or less gregarious, but little of interest is known about them in

Fig 1102.—Part of a Shoal of Herrings (*Clupea harengus*)

the present connection, so that we may pass on to the more intelligent animals included in the two highest vertebrate classes, *i.e.* Birds and Mammals. A comparatively large and complex brain is here associated with sagacity that may make itself manifest in social developments.

SOCIAL BIRDS (AVES).—Many Birds are eminently social in their habits, and migrant forms may be associated in vast numbers when making their long journeys (see p. 61). But we have yet much to learn regarding the way in which the living together of numerous individuals results in division of labour, or in concerted action. Of two closely related birds the one may

be solitary, and the other markedly gregarious, the Raven and the Rook affording a good instance of this. Each is adapted to its surroundings in a different way, and both adaptations are admirable of their kind, though possibly the social habit gives a better chance in the struggle for existence, and it certainly has a tendency to promote the development of comparatively high mental qualities. As elsewhere remarked (p. 107), the remarkable caste-system which distinguishes social insects has a serious penalty attached to it, for extreme specialization involves a loss of plasticity which, if surroundings change quickly, may mean extinction. But in social Birds and other Vertebrates improved mental powers may be expected to confer increased ability to cope with changing surroundings, and a community of the kind does not suggest a complicated machine easily thrown out of gear, as a nest, say, of Termites, irresistibly does.

As an example of a common social bird we may take the Rook (*Corvus frugilegus*), where there is abundant evidence to show that individuals may render services to the community, and that there may be co-operation to bring about certain common ends. We must, however, receive with caution some of the accounts that have been given of these crafty birds, and which would endow them with almost human attributes. It would appear that when raiding cultivated fields they commonly set sentinels on adjoining trees, and these worthies promptly give warning in raucous tones of the approach of danger in the shape of an agriculturalist. They certainly seem to have acquired knowledge, based on painful experience, of the lethal properties of firearms. Bernard observed Rooks co-operating to hunt field-voles, and his observations are thus summarized by Houssay (in *The Industries of Animals*):—
"His curiosity was excited by the way in which numerous rooks stood about a field cawing loudly. In a few days this was explained: the field was covered with rooks; the original assemblage had been calling together a mouse-hunt, which could only be successfully carried out by a large number of birds acting in conjunction. By diligently probing the ground and blocking up the net-work of runs, the voles, one or more at a time, were gradually driven into a corner. The hunt was very successful, and no more voles were seen in that field during the winter." The social nesting-habits of Rooks are familiar to all, for the cheerful sights and sounds of the rookery lend to the country a

CRESTED PENGUINS OR ROCK-HOPPERS
(*Eudyptes chrysocome*)

Penguins are more thoroughly aquatic than any other existing birds, their wings having been converted into paddles of great efficiency, though entirely useless for purposes of flight. The group is characteristic of the Southern Hemisphere, and practically limited to the shores of the Antarctic Ocean. The species represented is the Crested Penguin or Rock-hopper (*Eudyptes chrysocome*), which ranges from the Falkland Islands to New Zealand. It is a handsome black and white bird, with an orange-coloured crest on either side of the head. Like so many sea-birds the Rock-hoppers are social in habit. Their favourite breeding grounds are boulder-strewn slopes at some little distance from the sea, and near fresh water, in which they are fond of bathing. The nest is often a mere hollow scratched in the earth, though stems and leaves may be roughly drawn together to form it. The Rock-hopper, like Penguins generally, broods over its eggs in an erect or semi-erect position, bringing them into contact with a bare patch on the under side of the body, an arrangement which secures a maximum of heat.

CRESTED PENGUINS OR ROCK-HOPPERS (EUDYPTES CHRYSOCOME)
ON THE SHORES OF THE ANTARCTIC OCEAN

charm of their own (fig. 1103). The following vivid account given by Dixon (in *Among the Birds in Northern Shires*) will call up pleasant memories to the minds of many readers:— "And then their home in the cluster of elm-trees yonder is a place fraught with interest if full of noise. Towards the close of February, or, if the weather be still inclement, not until the

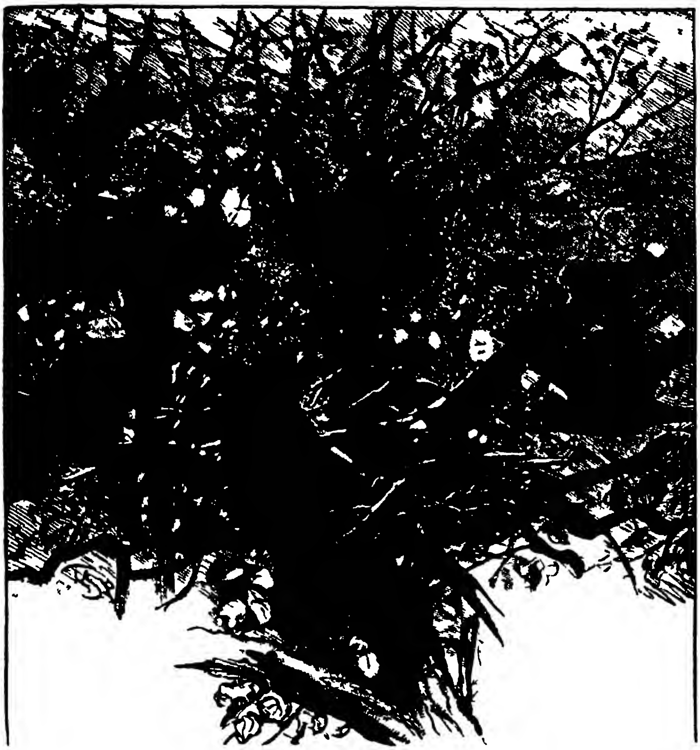


Fig 1103 —A Rookery

beginning of March, and at least a fortnight or three weeks later than in Devonshire, the rooks begin to tidy up their big nests in the slender branches at the tree-tops. Others, less fortunate, commence to build entirely new nests. But this building is by no means universal for a week or more; the mania for collecting sticks and turf has not yet spread through the entire colony, and numbers of birds may be seen looking on with indifference at the efforts of more industrious neighbours. What a noisy

animated scene the old rookery is for the next month, until the eggs are laid in the big massive nests; then there is comparative quietness until the young are hatched, when the noisy clamour begins again with greater volume until nestlings and parents get on to the adjoining fields. They return in many cases to the nest trees to roost, and then each evening the din is deafening as troop after troop of tired birds come straggling in from all directions and caw themselves hoarse before dropping off to sleep in the tall trees." The Social Grosbeak has been spoken of in an earlier section as a remarkable example of social nesting-habits (see vol. iii, p. 463).

The social habit is not infrequently conducive to successful defensive measures against enemies. Birds of the swallow kind will unite together to "mob" a hawk that ventures too near their nests, and other instances might easily be given.

Recognition Marks in Birds.—It is obviously advantageous for the members of a community of animals to be able to recognize one another with ease and certainty. They are safer, on the whole, when they keep together, for approaching danger is pretty sure to be perceived by some of them, and these individuals are able to communicate the fact to their fellows. Co-operation in the pursuit of food is also promoted, and, in migrant species, long journeys are more likely to be successfully made in fairly close order.

Wallace has given the name of "recognition marks" to certain colour-arrangements which appear to be of importance in the present connection, and he speaks as follows about the matter (in *Darwinism*).—"Among birds, these recognition marks are especially numerous and suggestive. Species which inhabit open districts are usually protectively coloured; but they generally possess some distinctive markings for the purpose of being easily recognized by their kind, both when at rest and during flight. Such are, the white bands or patches on the breast or belly of many birds, but more especially the head and neck markings in the form of white or black caps, collars, eye-marks, or frontal patches . . . (see fig. 1104). Recognition marks during flight are very important for all birds which congregate in flocks or which migrate together; and it is essential that, while being as conspicuous as possible, the marks shall not interfere with the general protective tints of the species when at rest. Hence they

usually consist of well-contrasted markings on the wings and tail, which are concealed during repose, but become fully visible when the bird takes flight. Such markings are well seen in our four British species of shrikes, each having quite different white marks on the expanded wings and on the tail-feathers; and the same is the case with our three species of Saxicola the stone-chat, whin chat, and wheat-ear which are thus easily recognizable on the wing, especially when seen from above, as they would be by stragglers looking out for their companions. . . . Those birds

Fig 1104.—1, Lesser Tern (*Sterna minuta*) and 2, Ringed Plover (*Aegialitis hiaticola*)

which are inhabitants of tropical forests, and which need recognition marks that shall be at all times visible among the dense foliage, and not solely or chiefly during flight, have usually small but brilliant patches of colour on the head or neck, often not interfering with the generally protective character of their plumage. Such are the bright patches of blue, red, or yellow by which the usually green Eastern barbets are distinguished, and similar bright patches of colour characterize the separate species of small green fruit-doves. To this necessity for specialization in colour, by which each bird may easily recognize its kind, is probably due that marvellous variety in the peculiar beauties of some groups of birds." If we admit the truth of the view just set forth, it follows that, in many birds, comparatively slight differences in plumage will often prove a safe guide in the discrimination of species. Though trivial in themselves they may nevertheless

be regarded as natural "labels", which indicate the presence of other specific differences that may be much more difficult to detect. The theory of recognition marks is strongly supported by the fact that animals which turn white in winter commonly do not do so completely, but retain small dark patches. The Ptarmigan (*Lagopus mutus*, fig. 1105), for example, retains black markings on the side of the tail, while the male in winter plumage is further distinguished by black streaks near the eye.

Social Mammals (Mammalia).—A large number of mammals affect the gregarious habit, and some examples of the benefits

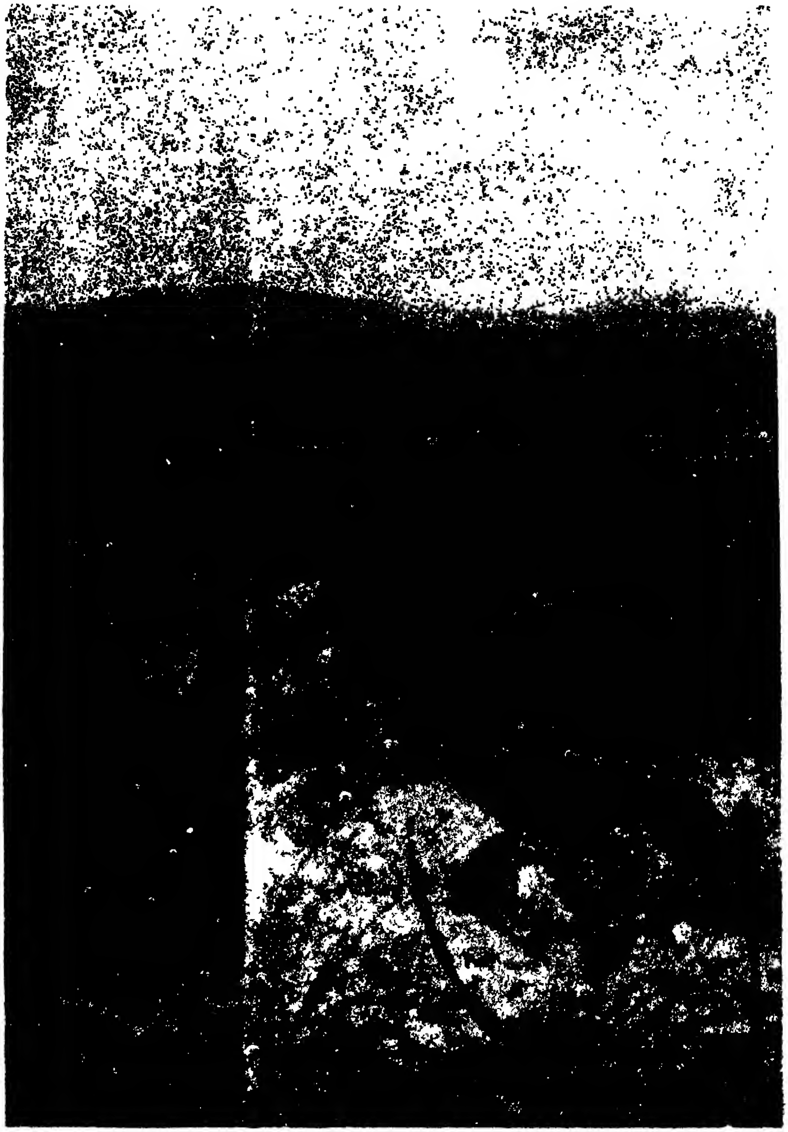
Fig. 1105.—Male Ptarmigan (*Lagopus mutus*) in Winter Plumage

accruing have elsewhere been given. Wolves, for example, hunt in packs, and sometimes secure their prey by very ingenious devices (see vol. ii, p. 16). The herding together of various Hoofed Mammals is distinctly of advantage in defence, and many such forms post sentinels to warn them of approaching danger (see vol. ii, p. 365). Troops of Baboons and Monkeys make well-organized raids, while their tactics during retreat from foes are often decidedly skilful, and have reference to the well-being of the community (see vol. ii, p. 363). The cubs of the Fur-Seal benefit by the mode of life in their "rookery" (see vol. iii, p. 492). To consider in detail all the groups of mammals in regard to social habits would be an almost endless task, and the present purpose will perhaps be sufficiently served by taking one or two typical and interesting cases.

PRAIRIE DOGS (*Cynomys Ludovicianus*)

These animals have received their somewhat inappropriate name from the curious way in which they "bark" on the approach of danger, but in reality there is nothing dog-like about them, for they are social burrowing Rodents or Gnawing Mammals, not distantly allied to the Marmots of the Old World. They are among the most characteristic inhabitants of the great plains to the east of the Rocky Mountain Highland in North America The earth thrown out from each burrow is heaped up into a mound that serves as a sort of watch-tower, on which a sentry may be posted.

The Rattlesnake or the Burrowing Owl may take possession of a burrow, but the old idea that snake, bird, and prairie-dog live together in the same quarters on amicable terms is quite untenable.



PRAIRIE DOGS (CYNOMYS LUDOVICIANUS) AT HOME

The Common Prairie-Marmot (*Cynomys Ludovicianus*), more familiarly known as the Prairie-"Dog", on account of the barking sound to which it gives utterance when alarmed, is a social burrowing rodent native to the dry open plains on the east of the Rocky Mountain highland. Several individuals live together in the same burrow, and a very large number of these homes may be associated together into a "city". The excavated earth is partly heaped up into a mound at the entrance to the burrow, and this may almost be called a watch-tower, since it is commonly occupied by a sentinel, who performs the usual duties of his office. On hearing his warning bark the neighbouring individuals scuttle down into their underground dwellings. The opening of each burrow is somewhat funnel-shaped, some of the earth dug out having been regularly arranged round it, and pressed together till firm: the use probably being to prevent flooding out during sudden showers. Owing to the fact that Burrowing Owls and Rattlesnakes are not infrequently found in the dwellings of this rodent, the conclusion has somewhat hastily been drawn that the three kinds of animal constitute a kind of "happy family", living together on the best of terms. This, however, is not the case, for the Owl simply takes possession of a deserted burrow, while the Rattlesnake appropriates one at random, ejecting the rightful owner if necessary, and thereafter visits his neighbours, levying a tax upon their offspring. The Common Prairie-Marmot is about a foot in length, exclusive of the short tail, but a larger and a smaller species are also indigenous to North America. The former is the Mexican Prairie-Marmot (*C. Mexicanus*), while the smaller sort is the Columbian Prairie-Marmot (*C. Columbianus*), which inhabits higher ground in the western part of North America. Their habits are much the same as those of the common form. It appears that there is a winter-sleep in the case of individuals which live pretty far north. The True Marmots (species of *Arctomys*) are somewhat larger animals allied to the preceding, and like them gregarious burrowers. They have a wide range through the northern parts of North America and Eurasia, living on plains except in the southern part of their distributional area, where they are typical mountain-animals. It is a familiar fact that they indulge in a long winter-sleep.

The Beaver (*Castor fiber*) is a very large social Rodent which formerly had a wide extension in Europe and North America,

but has been hunted down to such a deplorable extent, chiefly for the sake of its fur, that it now exists in greatly diminished numbers, and in all probability will become extinct at no distant period, except in cases where it is strictly preserved. It was once a native of Great Britain, though its range never extended to Ireland. According to Geraldus Cambrensis it lived in the river Teifi (Cardiganshire) so late as 1188, and is thought to have survived in Scotland to a still later period. The American Beaver is probably a distinct species (*C. Canadensis*), and its habits have been more carefully studied than those of the European kind. The animal is an expert swimmer and diver, being modified in structure in connection with this habit, as elsewhere described (see vol. iii, p. 73). In all probability it was originally a bank-dweller, excavating an upwardly sloping burrow, with the top end expanded into a living chamber, and the entrance below the surface of the water. And where this unfortunate animal is subjected to much persecution its architectural efforts do not attain anything of more elaborate nature. Under normal circumstances, however, much more complex homes are made, which may be regarded as having been evolved by gradual stages from the primeval burrow. They involve the construction of "dams" and "lodges", a narrow stream being converted by the former into a series of ponds, of which the surface-level remains fairly steady, thus giving favourable conditions for building the lodges or houses. It is essential that the district should be well wooded, as the chief material used in making the dams consists of the trunks and branches of trees, some of which may be as much as 40 inches round at the base and 120 feet high. The tools employed are the powerful incisor teeth, and a tree is felled by being bitten round in a neat manner near the ground. As H. T. Martin says (in *Castorologia*):—"No better work could be accomplished by a most highly-finished steel cutting tool, wielded by a muscular human arm".

Trees growing near water usually slant towards it, and when sufficiently weakened by the gnawing process must, as a rule, fall that way. It was once supposed that the Beaver secured this end by biting more wood from the side facing the stream, but this appears to be incorrect. When the tree is felled its branches are gnawed off, and the timber is cut up into lengths of five or six feet, the bark being peeled off to serve as food. It is, indeed,

quite possible that the habit of bark-feeding was the original one, and that the use of the wood for constructive purposes has been evolved subsequently. The process described provides for the framework of a dyke, and twigs, &c., are added, together with much earth. The nature of the work is adapted to the local conditions: in the case of brooks or large streams with ill-marked banks there is a "stick-dam", in which the earth is of comparatively small amount: where the water is deeper and the banks clearly defined there is a "solid-bank dam", with enough earth to cover up all the woody framework. In the former case no special channel is made through which the water may make its way, while in the latter case a suitable exit is scooped out on the top of the dyke. In order the better to resist water-pressure, the upper side of the barrier is sloping; its lower surface is approximately vertical. The foundation is from about 9 to 12 feet, the upper part about 2 feet in thickness. The dam is built straight across if the current is gentle, while the greater pressure existing in a rapid stream is compensated by making the work curved, with its convex side facing upwards. The following careful account of this preliminary engineering work is given by Lewis H Morgan (in *The American Beaver and his Works*), and it will be noted that he does not favour the common view that several or a large number of families co-operate for the benefit of the "village" —"The dam is the principal structure of the beaver. It is also the most important of his erections as it is the most extensive, and because its production and preservation could only be accomplished by patient and long-continued labour. In point of time, also, it precedes the lodge, since the floor of the latter and the entrances to its chamber are constructed with reference to the level of the water in the pond. The object of the dam is the formation of an artificial pond, the principal use of which is the refuge it affords to them when assailed, and the water connection it gives to their lodges and to their burrows in the banks. Hence, as the level of the pond must, in all cases, rise from one to two feet above these entrances for the protection of the animal from pursuit and capture, the surface-level of the pond must, to a greater or less extent, be subject to their immediate control. As the dam is not an absolute necessity to the beaver for the maintenance of his life, his normal habitation being rather natural ponds and rivers, and

burrows in their banks, it is, in itself considered, a remarkable fact that he should have voluntarily transferred himself, by means of dams and ponds of his own construction, from a natural to an artificial mode of life. Some of these dams are so extensive as to forbid the supposition that they were the exclusive work of a single pair, or of a single family of beavers; but it does not follow, as has very generally been supposed, that several families, or a colony, unite for the joint construction of a dam. After careful examination of some hundreds of these structures, and of the lodges and burrows attached to many of them, I am altogether satisfied that the larger dams were not the joint product of the labour of large numbers of beavers working together, and brought thus to immediate completion; but, on the contrary, that they arose from small beginnings, and were built upon year after year, until they finally reached that size which exhausted the capabilities of the location; after which they were maintained for centuries, at the ascertained standard, by constant repairs. So far as my observations have enabled me to form an opinion, I think they were usually, if not invariably, commenced by a single pair, or a single family, of beavers; and that when, in the course of time, by the gradual increase of the dam, the pond had become sufficiently enlarged to accommodate more families than one, other families took up their residence upon it, and afterwards contributed by their labour to its maintenance. There is no satisfactory evidence that the American beavers either live or work in colonies; and if some such cases have been observed, it will either be found to be an exception to the general rule, or in consequence of the sudden destruction of a work upon the maintenance of which a number of families were depending. The great age of the larger dams is shown by their size, by the large amount of solid materials they contain, and by the destruction of the primitive forest within the area of the ponds; and also by the extent of the beaver-meadows all along the margins of the streams where dams are maintained, and by the hummocks formed upon them by and through the annual growth and decay of vegetation in separate hills. These meadows were undoubtedly covered with trees adapted to a wet soil when the dams were constructed. It must have required long periods of time to destroy every vestige of the ancient forest by the increased saturation of the

earth, accompanied with occasional overflows from the stream. The evidence from these and other sources tends to show that these dams have existed in the same places for hundreds and thousands of years, and that they have been maintained by a system of continued repairs.

"At the place selected for the construction of a dam the ground is usually firm and often stony, and when across the channel of a flowing stream, a hard rather than a soft bottom is preferred. Such places are necessarily unfavourable for the insertion of stakes in the ground, if such were, in fact, their practice in building dams. The theory upon which beaver-dams are constructed is perfectly simple, and involves no such necessity. Soft earth, intermixed with vegetable fibre, is used to form an embankment, with sticks, brush, and poles imbedded within these materials to bind them together, and to impart to them the requisite solidity to resist the effects both of pressure and of saturation. Small sticks and brush are used, in the first instance, with mud and earth and stones for down-weight. Consequently these dams are extremely rude at their first commencement, and they do not attain their remarkably artistic appearance until they have been raised to a considerable height, and have been maintained by a system of annual repairs for a number of years."

The beaver-house or "lodge" is a domed structure, constructed of clay and wood on the upper side of the dam. A lodge is from 6 to 8 feet high, and its base is 9 to 12 feet broad, or rather more. The living-room within, which also serves as a "nursery", is lined with grass, and its floor is at water-level. There are several entrances which open well below the surface, so that there is no danger of blockage by ice during the winter. The beaver does not hibernate, and its pond is deep enough to enable it to swim about under the surface of the ice in the most rigorous seasons. The lodge includes a store-chamber, in which large quantities of the succulent rhizomes of certain water-lilies are heaped up for winter use. Tree-branches are also accumulated in the deeper parts of the pond for the same purpose. Martin (in *Castorologia*) makes the following interesting remarks regarding the popular misconception as to the highly-finished character of the lodge, and also as to the way in which it has evolved from the simple burrow:—"The beaver-lodge is generally included in the list of marvels reserved for the investigation

of those who visit beaver-districts, and yet no greater disappointment awaits the inquirer than the first inspection of one. Somehow the minds of all lovers of natural history become affected by the fabulous accounts concerning this structure, and it is a shock to stand for the first time before a pile of twigs, branches, and logs, heaped in disorder upon a small dome of mud, and to learn that this constitutes the famous lodge. Of course the superficial glance does not convey all that can be learnt in connection with this work, but it does most completely disillusionize the mind. On breaking through the upper walls, the interior is found to be similar to the general type of an animal's sleeping apartment, and has scarcely any distinguishing characteristic. . . . Starting with the simple burrow, the next step is the accumulation of logs and branches about its entrance, forming what is called a 'bank-lodge'. In places where the water is shallow towards the shore, a great advantage would be derived from extending this artificial covering of brushwood, so that in time a natural evolution of the lodge disconnected entirely from the shore would take place, and form an independent and very convenient refuge from landward enemies." It may be well to add that the large flattened tail of the beaver is a swimming organ, and is not employed as a trowel. Clay is manipulated entirely by means of the fore-paws.

Recognition Marks and Odours.—Many of the gregarious Mammals possess contrasted light and dark markings which possibly enable the individuals of the same species to recognize one another, as in the similar cases already described for birds (p. 132). The most familiar instance is the white patch on the under side of a Rabbit's tail, which, though it does not interfere with the general protective character of the coloration, makes the animal easily seen when it moves rapidly. On this account it has also been described as an illustration of "signalling coloration", by which, when retreating from danger, an unconscious warning is given by the animal to its fellows. Other instances cited by Wallace (in *Darwinism*) are antelopes (fig. 1106), zebras, monkeys, and lemurs. In regard to the first of these, he suggests that the great variety in the shape of the horns has to do with recognition.

Gregarious Mammals are commonly distinguished by the possession of a keen sense of smell, which has various relations to habits. In herbivorous forms, for instance, it is of great

importance with reference to detecting the approach of carnivores. But it would also seem to play a part in facilitating mutual recognition between individuals of the same kind. At any rate we often find that social forms are provided, in various parts of the body, with peculiar glands, the secretions of which emit

Fig. 1106.—Hartebeest (*Bubalis caama*)

characteristic odours, often, to us, of disagreeable kind. The Rabbit (*Lepus cuniculus*) is a case in point, for its "rabbity smell" is due to the products of a pair of glands (perineal glands) in the hinder part of the body. The little Peccaries (*Dicotyles*) of South America possess a good-sized gland under the skin of the back, the secretion being here a stinking oily fluid, the emanations from which no doubt assist in keeping the members of a troop together.

There is good reason why they should, for, as Beddard says (in *The Cambridge Natural History*), "they owe, too, their safety from many foes to their sociable habits. Being nocturnal animals they are liable to the attacks of the jaguar, which will speedily overpower and devour a peccary that has strayed from its herd."

In Deer there is usually a scent-gland (the *crumen*) opening into a pit below the eye; so also in most Antelopes. The latter may also possess other scent-glands in the groin or between the toes. Bottle-shaped structures of the sort are found between the digits in Sheep (fig. 1107). It is interesting to note that a captive specimen of the Klipspringer Antelope (*Oreotragus saltator*) has been observed to deliberately deposit upon various objects the secretion that oozes out under its eyes. Such a habit if practised under natural conditions would no doubt help these animals to find one another. But the glands in the feet of Sheep, &c., are of special interest here, for drops of the strong-smelling secretion must constantly be squeezed out on to the ground, leaving a well-marked "trail".

Fig. 1107.—Foot of Sheep (*Ovis aries*) dissected to show scent gland, the opening of which is indicated by an arrow

Many other examples of scent-glands might easily be given. The exact use no doubt varies in different cases, and may have nothing to do with the social habit proper. For example, an animal may thus be assisted in the search for a mate, and Beddard suggests that some scents are possibly of mimetic nature. The odour of the Musk-Deer is perhaps of this kind, for it may suggest to aggressors the musky smell of the Crocodile, an animal which they would think twice before attacking. Stink-glands as a direct defence have been spoken of elsewhere (see vol. ii, p. 301).

CHAPTER LXIV

ASSOCIATION OF ORGANISMS—COURTSHIP AND MATING

It is well known that among a number of savage tribes well-developed thews and sinews are an invaluable possession to a young man inclined towards matrimony; he has, in short, to fight for a wife. Among civilized human communities good looks play no unimportant part in the matter, though financial considerations are sometimes said to be paramount. We have, in fact, the Law of Battle and the Law of Beauty, both very clearly enunciated by Darwin in the case of animals, and illustrated by a wealth of fact. The former law is admitted by all to have great influence in many cases in deciding which individuals shall mate together, but Wallace, whose opinion in all zoological matters is entitled to the greatest respect, does not think that ornamental males are preferred as partners by those of the opposite sex. The part of his argument, so far as the human species is concerned, is thus expressed (in *Darwinism*):—"A young man, when courting, brushes or curls his hair, and has his moustache, beard, or whiskers in perfect order, and no doubt his sweetheart admires them; but this does not prove that she marries him on account of these ornaments, still less that hair, beard, whiskers, and moustache were developed by the continued preferences of the female sex. So, a girl likes to see her lover well and fashionably dressed, and he always dresses as well as he can when he visits her; but we cannot conclude from this that the whole series of male costumes, from the brilliantly-coloured, puffed, and slashed doublet and hose of the Elizabethan period, through the gorgeous coats, long waist-coats, and pigtails of the early Georgian era, down to the funereal dress-suit of the present day, are the direct result of female preference." One is inclined to believe, however, that an average girl does prefer a good-looking young man, and that female preference has had a directive influence on the evolution of male

attire. And there are so many facts supporting the view that the females of many animals are influenced by the ornamental endowments of prospective partners, that the existence of the Law of Beauty will be here taken as provisionally proved. At the same time it must not be applied to explain facts in too sweeping a manner. Every case should be considered on its own merits, and our knowledge of animal habits is so very imperfect that it is easy to fall into error. It is also necessary to carefully avoid the pitfall of unconsciously assuming that the mental endowments of lower animals closely resemble our own. There is no reason to think, for example, that a hen-bird exerts a deliberate choice in the selection of a mate. She may be strongly attracted towards one of several possible partners, and beauty of plumage or voice may have to do with such attraction, but that is not the same thing as "deliberate choice" in the usual sense.

It is only among comparatively specialized animals that the Laws of Battle and Beauty are exemplified, and a few examples will fittingly illustrate the subject.

COURTSHIP AND MATING OF MAMMALS (MAMMALIA)

THE LAW OF BATTLE.—A complete list of species in which the males fight in order to secure mates would be a fairly complete catalogue of Mammals, for in this class the question of Beauty would appear to be subordinate. One would naturally expect combats to be most frequent in cases where the females were comparatively few in number, but as a matter of fact it is better marked among polygamous species, which are necessarily social, though it by no means follows that all gregarious animals are polygamous. Deer and various other Hoofed Mammals afford good illustrations, and as these lead a wandering life it is possible that the practice of polygamy has arisen from the desirability of keeping a herd together, an end to which it is more favourable than monogamy. In nearly all species of Deer the males alone possess antlers, and this is correlated with the fact that they fight furiously together in the struggle to secure mates. In the case of our native Red Deer (*Cervus elaphus*) the adult stags live by themselves except for about three weeks in the autumn, this being the mating-season. Fierce combats are then frequent, that result in the discomfiture of the weaker males, some of which may be

killed outright. Every victor is able to secure a number of partners, but he has to be continually on the look-out to repel other stags wishing to interfere with his family life, and may have to yield his privileges to an intruder. Might as usual is the only right.

The Law of Beauty.—Adult male Mammals are not infrequently distinguished from those of the other sex by the possession

Fig. 1108.—Male Mandrill (*Papio mormon*)

of various ornaments, among which may be mentioned the mane of the Lion and the beard of the Goat. An extreme case is presented by the West African Baboon known as the Mandrill (*Papio mormon*, fig. 1108), the name of which probably means "man-like baboon". If so, it is rather a libel upon the human species, for the appearance of the adult male is decidedly startling. Either side of the face presents a furrowed blue swelling, the grooves being purple, while between these ornaments is a strip of bright red, passing down to the end of the nose, which is of the same lively hue. A pointed beard of orange yellow completes a scheme of colour that is effective in its way. The large bare

patches on the hinder part of the body are also of a vivid scarlet, with a tinge of blue. The teeth are of formidable nature, as in many apes and monkeys, the canines being particularly large, partly no doubt with reference to defence, but partly also in relation to combats with other males of the same species. The female Mandrill is faded-looking in comparison to her mate. The swellings on her face are comparatively small and pale, while there is never more than a faint display of red.

The attractions of male mammals often include a relatively well-developed voice, as in the Red Deer, where during the mating season the stag makes a characteristic roaring sound, known as "belling", though whether this serves any special purpose is doubtful. The last remark also applies, it would seem, to the American Howling Monkeys, regarding one of which Darwin thus speaks (in *The Descent of Man*):—"The vocal organs of the American *Mycetes caraya* are one-third larger in the male than in the female, and are wonderfully powerful. These monkeys in warm weather make the forests resound at morning and evening with their overwhelming voices. The males begin the dreadful concert, and often continue it during many hours, the females sometimes joining in with their less powerful voices. An excellent observer, Rengger, could not perceive that they were excited to begin by any special cause; he thinks that, like many birds, they delight in their own music, and try to excel each other." One is irresistibly reminded here of the "dreadful concerts" held nightly by the common Cat. The males appear to take the leading parts, and their unearthly cries seem to express defiance of one another, rather than to be a means of attracting the softer sex.

COURTSHIP AND MATING OF BIRDS (AVES)

THE LAW OF BATTLE.—Most male birds are exceedingly pugnacious, fighting for the possession of mates in the most determined manner, the habit being perhaps best-marked in the polygamous species. They may be provided with special weapons, the spurs of cocks being a familiar example. The methods of fighting of some birds are described as follows by Brehm (in *From North Pole to Equator*):—"Rival ostriches fight with their strong legs, and, striking forwards, tear deep wounds with their sharp toe-nails in the breast, body, and legs of their

opponent. Jealous bustards, after spending a long time challenging each other with throat inflated, wings and tail outspread, and much grumbling and hissing, make use of their bills with very considerable effect. Sand-pipers and other shore-birds, particularly the fighting ruffs, which fight about everything, about

Fig. [illegible].—Cock Chaffinches Fighting

a mate or about a fly, about sun and light, or about their standing-ground, run against each other with bills like poised lances, and receive the thrusts among the breast feathers, which in the case of the ruffs are developed into what serves as a shield [much as in the Lion]. Coots rush at each other on an unsteady surface of water-plants, and strike each other with their legs. Swans, geese, and ducks chase each other till one of the combatants

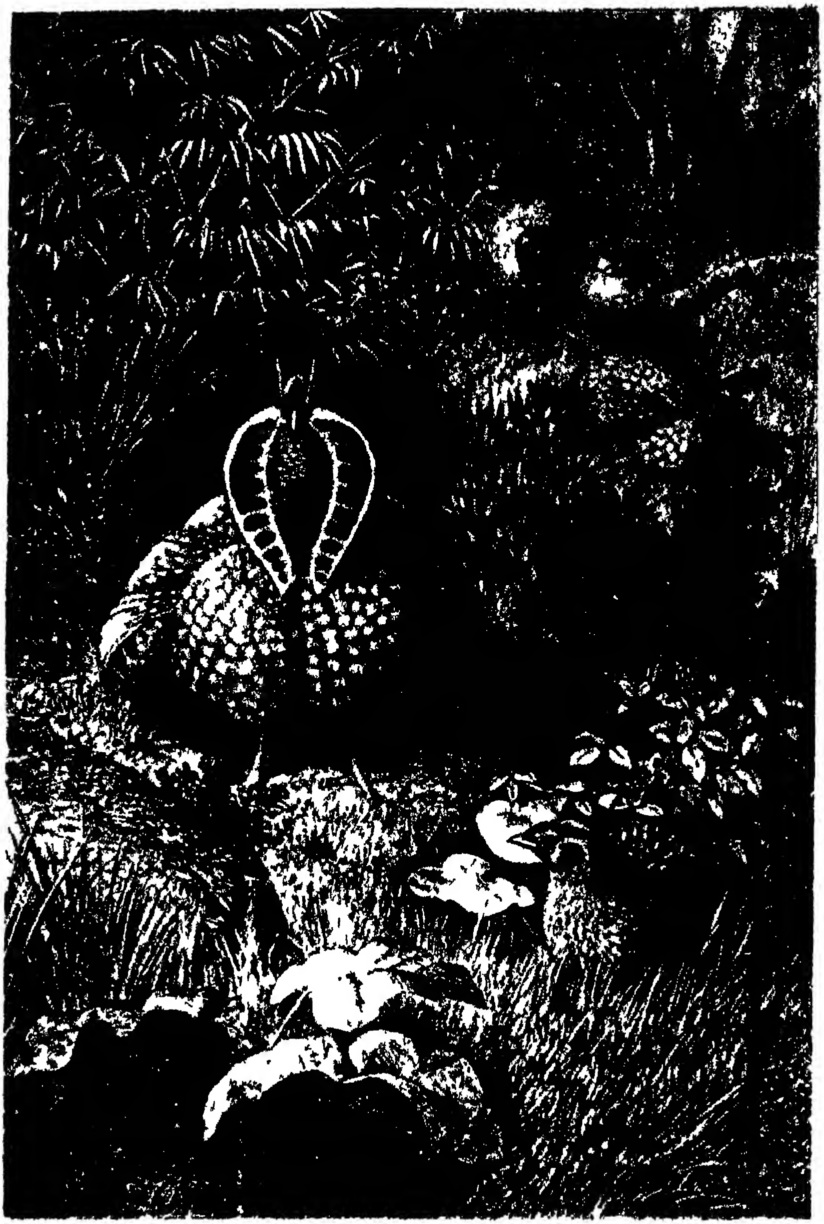
succeeds in seizing the other by the head and holding him under water, till he is in danger of suffocating, or at least until he is so much exhausted that he is unable to continue the struggle."

A battle-royal between two cock chaffinches is represented in fig. 1109.

THE LAW OF BEAUTY.—It is familiar to all that male birds very often differ markedly from the females in the possession of more ornamental characters, and a more powerful or more beautiful voice. And it is significant that their charms are in full perfection at the time of mating. The contrast between the sexes is obvious on looking round any poultry-yard. Among ordinary fowls the striking plumage of the cock, and his scarlet wattles and comb, make him a handsome bird by contrast with the rather dowdy hen. The drake is distinctly handsomer than the duck. But such examples are far excelled by some of the allies of domesticated fowls, for in many of these the plumage of the male is beautiful beyond mere verbal description. Such in particular are the Golden Pheasant (*Chrysolophus pictus*), Amherst's Pheasant (*C. Amherstiæ*), the Argus Pheasant (*Argusianus giganteus*), and the Peacock (*Pavo cristatus*). Gorgeously decorated male birds of the sort display their charms during courtship in a remarkable manner. We may take as an example the Scarlet Tragopan (*Tragopan satura*), of which the following description by Ogilvie Grant (in *The Royal Natural History*) will convey some idea of the brilliancy of the colour-scheme:—"The male has the top and sides of the head black, the neck, mantle, and under-parts orange-carmine, and the rest of the upper parts olive-brown, each feather being ornamented at the tip with a round white spot, partially or entirely margined with black; the outer wing-coverts being edged on each side with dark orange-carmine. The throat-wattle is salmon-colour with transverse blue bars, and the legs are pale flesh" Brehm, after describing the love-dances of various birds, thus speaks (in *From North Pole to Equator*) of this particular form:—"More remarkable than all the rest is the behaviour of the male tragopans or horned pheasants of Southern Asia, magnificently decorative birds, distinguished by two brightly-coloured horn-like tubes of skin on the sides of the head, and by brilliantly-coloured extensible wattles. After the cock has walked round the hen several times without appearing to pay any attention to her, he stands still at

COURTING OF THE TRAGOPAN (*Ceriornis satyrus*)

Among highly organized groups of animals the male is commonly more beautiful than his partner, and the matrimonial chances of the former are supposed to be often proportionate to his decorative endowments. According to this view the æsthetic taste of females has had an important influence in the evolution of male adornments. The Horned Pheasant (*Ceriornis satyrus*) or Tragopan of Northern India, which is one of a small group of extremely handsome species, affords a good illustration of the striking difference in appearance which often distinguishes the sexes. As will be gathered from the plate, the hen bird (in the foreground) is comparatively drab, but the cock possesses ornaments of an uncommon order, which he is represented as fully displaying with a view of securing the favour of a desired partner. His ornaments include a couple of blue outgrowths on the head which can be made to stick up like horns, and a pair of brilliantly coloured wattles capable of inflation to form a sort of horse-shoe shaped collar. Details of the colour scheme and of the love antics are given in the text.



THE HORNED PHEASANT (CERIORNIS SATYRUS) OR
TRAGOPAN OF NORTHERN INDIA

a particular spot, and begins to bow. More and more quickly the courtesies follow each other, the horns meantime swelling and tossing, the wattles dilating and collapsing again, till all are literally flying about the head of the love-crazed bird. Now he unfolds and spreads his wings, rounds and droops his tail, sinks down with bent feet, and, spitting and hissing, lets his wings sweep along the ground. Suddenly every movement ceases. Bent low, his plumage ruffled, his wings and tail pressed against the ground, his eyes closed, his breathing audible, he remains for a while in motionless ecstasy His fully unfolded decorations gleam with dazzling brightness. Abruptly he rises again, spits and hisses, trembles, smooths his feathers, scratches, throws up his tail, flaps his wings, jerks himself up to his full height, rushes upon the female, and, suddenly checking his wild career, appears before her in olympic majesty, stands still for a moment, trembles, twitches, hisses, and all at once lets all his glory vanish, smooths his feathers draws in his horns and wattles, and goes about his business as if nothing had happened."

The combination of "spitting and hissing" with "olympic majesty" in the tragopan strikes one as somewhat lacking in dramatic fitness, from the human stand-point, but it serves as a reminder that the most gorgeously decorated male birds are not remarkable for beautiful voices. The unpleasant scream of the Peacock is no doubt familiar to all. On the other hand, the most gifted songsters are often modestly attired, and it is further to be noted that birds of small size are particularly notable in the matter of vocal attainments. In some cases, at any rate, love-songs would appear to prove more attractive to the female than elaborate colour-displays or amorous antics. On this point Darwin makes the following remarks (in *The Descent of Man*):—"Naturalists are much divided with respect to the object of the singing of birds. Few more careful observers ever lived than Montagu, and he maintained that the 'males of song birds and of many others do not in general search for the female, but, on the contrary, their business in the spring is to perch on some conspicuous spot, breathing out their full and amorous notes, which, by instinct, the female knows, and repairs to the spot to choose her mate'. Mr. Jenner Weir informs me that this is certainly the case with the nightingale. Bechstein, who kept birds during his whole life, asserts 'that the female canary

always chooses the best singer, and that in a state of nature the female finch selects that male out of a hundred whose notes please her most.' There can be no doubt that birds closely attend to each other's song." It seems, however, to be certain that birds take a delight in their musical powers quite apart from the question of courtship, often singing from emulation or from sheer "joy of life".

Fig. 1110.—Male Australian Bustard (*Otis australis*) with Throat-pouch inflated

It is almost superfluous to remark that in appraising the attractions of male birds we must remember that what to us is merely comical, may nevertheless be well adapted to its purpose. In the Common Bustard (*Otis tarda*), for instance, the male indulges in strange antics and displays of plumage, and often possesses a large pouch that can be dilated to serve as a resonator, no doubt making the love-call more sonorous, though this is no more than the syllable "oak" often repeated. The Australian Bustard (*Otis australis*, fig. 1110) also has such a pouch, which in this case is simply a greatly dilatable part of the gullet.

Odorous attractions are sometimes possessed by the male, as in the Musk-Duck (*Cairina moschata*), a species which ranges from Mexico to the Argentine Republic, and is known in captivity by the erroneous name of "Muscovy" Duck.

It must not be imagined that the courtship of any particular species necessarily exemplifies the Law of Battle or the Law of Beauty only, for in many cases strength and æsthetic qualities are both called into play.

COURTSHIP AND MATING OF REPTILES (REPTILIA)

THE LAW OF BATTLE.—Some male Reptiles engage in combats with one another during the mating season, a habit which has been observed in Alligators, some Tortoises, and certain

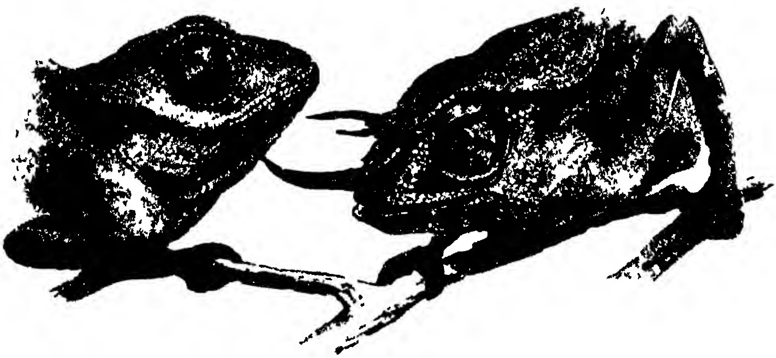


Fig. 1111.—Owen's Chameleon (*Chamæleo Oweni*). Female on left, male on right.

Lizards. Among the latter the males may be provided with strong spines or horns on the head, especially so in some of the Chameleons (fig. 1111), and these weapons are no doubt used in their fights with one another. The jealous ferocity of the American Alligator (*Alligator Mississippiensis*) is thus graphically touched off by Cyrus W. Butler (in *Big Game of North America*):—"On the whole, he is a sluggish, very sluggish, animal, not even being an active hunter; but loafs around in hope that something may turn up—that probably a fish may unwittingly swim near enough to be snapped up by a quick motion of his long jaws. But lazy and sluggish as he is, and cold as is his blood, there are times when it must course swiftly through his veins; for on a little island of muck, in the centre of a pond, a female

is heaping up a pile of saw-grass and dirt for a nest, while upon opposite sides of the pond, and just upon the edge of the saw-grass, eyeing her with warm glances of admiration, and each other with the sullen glare of hatred, lie two old males, whose scarred and bleeding bodies testify that even a 'gator's cold blood is thicker than water. The smaller one moves painfully, for his right fore-foot is missing — the larger one got his jaws upon it, a few rapid turns, and the foot was gone, probably soon buried in the stomach of the victor. The loss of a foot in fighting is quite common, for I have taken three thus maimed, and heard of others."

The Law of Beauty.—The most striking examples among Reptiles of relatively ornamental males is afforded by some of

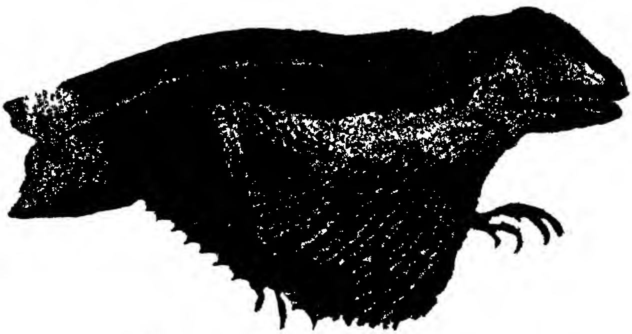


Fig. 1112.—Male Lizard (*Sitana*) with Throat-pouch

the Lizards. In certain Indian species of the genus Sitana (fig. 1112), for instance, the male is provided with a brilliantly-coloured throat-pouch,' which can be either folded up or dilated and is only fully displayed during the mating-season. It also appears that at this time the scent-glands of Crocodiles, Snakes, and Lizards are particularly active in the male.

COURTSHIP AND MATING OF AMPHIBIANS (Amphibia)

The Law of Battle.—Our information here is somewhat scanty, but male Frogs have been observed fighting together with great ferocity during the mating season, at which time also male Toads wrestle with one another in a determined manner, discomfited athletes being at a discount among the females.

The Law of Beauty.—Here we may take as an example

the Great Crested Newt (*Molge cristatus*, fig. 1113), which is one of our few native forms. During the time of courtship the male possesses a special adornment in the form of a high saw-edged crest on the upper side of his body and tail, besides which his colours are brighter than those of the other sex.

The vocal attractions of male Frogs are often considerable. In the Edible Frog (*Rana esculenta*), for instance, the male possesses a pair of croaking sacs at the corners of the mouth, which can be dilated to serve as resonators, imparting a mellow tone to his voice. The "concerts" of this and other species

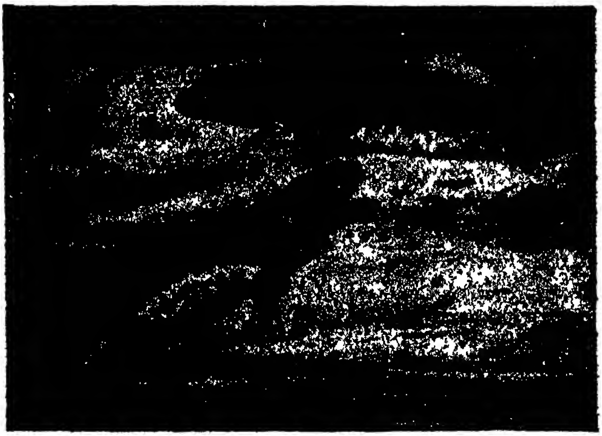


Fig. 1113.—Great Crested Newt (*Molge cristatus*). Male above, female below

are as striking in their way as the musical efforts of Howling Monkeys and some other Mammals. The following picturesque account of an evening performance of the kind is given by Thoreau (in *Walden*):—"In the meantime all the shore rang with the trump of bull-frogs, the sturdy spirits of ancient wine-bibbers and wassailers, still unrepentant, trying to sing a catch in their Stygian lake,—if the Walden nymphs will pardon the comparison, for though there are almost no weeds, there are frogs there,—who would fain keep up the hilarious rules of their old festal tables, though their voices have waxed hoarse and solemnly grave, mocking at mirth, and the wine has lost its flavour, and become only liquor to distend their paunches, and sweet intoxication never comes to drown the memory of the past, but mere saturation and water-loggedness and disten-

tion. The most aldermanic, with his chin upon a heart-leaf, which serves for a napkin to his drooling chaps, under this northern shore quaffs a deep draught of the once scorned water, and passes round a cup with the ejaculation *tr-r-r-oonk, tr-r-r-oonk, tr-r-r-oonk!* and straightway comes over the water from some distant cove the same pass-word repeated, where the next in seniority and girth has gulped down to his mark; and when this observance has made the circuit of the shores, then ejaculates the master of ceremonies, with satisfaction, *tr-r-r-oonk*, and each in his turn repeats the same down to the least distended, leakiest, and flabbiest-paunched, that there be no mistake; and then the bowl goes round again and again, until the sun disperses the morning mist, and only the patriarch is not under the pond, but vainly bellowing *troonk* from time to time, and pausing for a reply."

COURTSHIP AND MATING OF FISHES (PISCES)

THE LAW OF BATTLE.—During the spawning-season a number of male fishes are very pugnacious, fighting one another on the least provocation. We may take as examples the Salmon (*Salmo salar*) and Three-Spined Stickleback (*Gasterosteus aculeatus*). At the time when Salmon make their annual ascent of rivers the lower jaw of the mature male grows out into a sort of hook (fig. 1114), which is supposed to serve as a protection against the furious charges of his rivals, while at the same time his teeth become long and sharp, being frequently over half an inch in length. Two males have been observed fighting together a whole day, and the mortality is often considerable.

The little Stickleback is no less savage during the days of courtship, at which time he becomes of a vivid red colour, that has earned him the local name of "robin". Fred Smith (in *The Boyhood of a Naturalist*) thus graphically describes a combat:—"Oh, we needn't be so cautious in approaching, at least not this ditch, for the stickleback is monarch of all he surveys here; and though just a bit scared when our shadows fall athwart the water, he immediately reappears in a defiant attitude which there is no mistaking. I speak of 'he', because the only stickleback at present visible, and which I knew

I should find at the spot, is an acquaintance of quite long standing, and is a 'robin,' i.e. a gentleman stickleback as beautiful as he is brave. Now see him turn over and show himself when I drop in this little red worm: there, what a gorgeous crimson breast, with sides of brightest silver, and back like the sheen of a sunset sky, and eyes like points of living light! All this, in his efforts to master the poor worm's wriggling, or to break it in two before attempting to swallow. And now that is accomplished he takes his stand under that dense clump of weed (which contains his nest)! And here comes another stickleback,

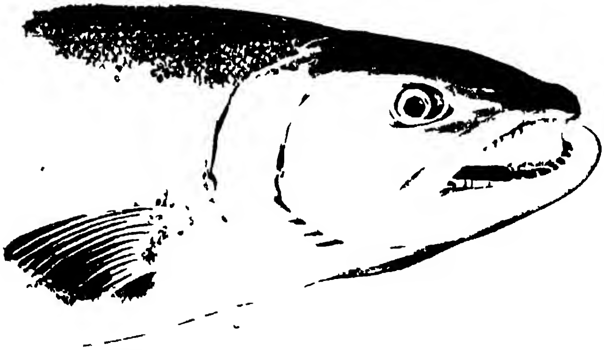


Fig. 1114. Head of Adult Male Salmon (*Salmo salar*), showing hooked lower jaw.

innocently looking for something to eat, and approaches within a foot of that clump of weed. Like a lightning flash the 'robin' shoots himself at the intruder, and she, a lady stickleback, turns one or two somersaults, goes very pale and almost transparent, and beats a precipitate retreat. This looks cruel, but he only meant to frighten the brazen female who dared to venture so near to his domain. See him now. Another 'robin' has approached, perhaps the husband of the frightened lady. Now it is war, now he is ready to be cruel if he can. Before we can think, green and crimson and golden lights play madly before our eyes; and this brilliant display is all that can be made out till it is suddenly resolved into two gorgeous robins, more brilliant than ever in their rage, their eyes very balls of fire, their dorsal and lateral prickles erect and red as though touched with fire. Only an instant are they quiet, when our older friend renews the attack with such ferocity that our later acquaintance deems

discretion the better part of valour, and, not in too great a hurry, but with a certain dignity, follows his lady-love, to whom he no doubt describes the tremendous thrashing he has given to her ungallant molester." Lloyd Morgan (in *Animal Sketches*) gives the following very interesting account of a complete stickleback love-story, the scene being an aquarium:—"I began by putting into one of my glass tanks, in which there grew sufficient healthy weed to ensure the purity of the water, a male Thornie and three females. The male was just beginning to assume the bright colours (blue and crimson and creamy white) of courtship. But the largest and stoutest of the females bullied him so unmercifully—reversing the usual order of things *among sticklebacks*—that in two days he was utterly dejected and crestfallen, and had completely lost all sign of colour. I then put into the same tank another male. Him, too, the irascible old lady bullied unmercifully, pulling his fins and his tail in the most vulgar fashion, until he leapt out of the water in his agony. I felt that such conduct could not be allowed. It pained me to see my little friend treated worse than 'the Private Secretary', and that by a lady whom he would fain have made his wife. I therefore removed the offending party, and kept her in solitary confinement in a separate tank, introducing in her stead one quieter and less quarrelsome. This was at about ten o'clock in the morning. But I shortly found that there was a new element of difficulty in getting my finned family to dwell together in peace and harmony. After some slight angry skirmishing, the two little males began a regular downright battle, using freely the strong spines which form the outer rays of the ventral fins. Never were seen more infuriated little monsters. It was, however, soon evident which was master, for ere long the victor was chasing the vanquished round and round the tank, seizing him at times by the pectoral fin, holding on and shaking him like a young bull-dog, the three females timidly looking on the while. At about three o'clock the victor's angry passions began to subside to some extent. He still had a suspicious mien; but with well-feigned nonchalance he began to carry about somewhat aimlessly any little bits of stick or broken pieces of alga he could find, as though he thus intended to proclaim that, now he was master of that tank, he was going to settle down there and build his nest. He was, however, evidently too perturbed

in his mind to do any serious work, for he continually left off to go and give the other fellow an additional bit of a drubbing; so that at five o'clock I took pity on the dejected little fish, and removed him to another tank. (A description of the way in which the victorious male built a nest here follows. See vol. iii, p. 428.) He was by this time in glorious colour, bright red all over the gills and along the ventral region, light creamy pink or blue on the back, his eye a very sapphire for brightness and purity of blue. Yet would not his mates be coaxed to the nest. Dress as he might, and air his finery as he would, they remained obdurate, insensate, and unmoved. Then would he show his not unnatural pique and annoyance by running at them from a distance and giving them most ungallant digs in the ribs. This is, however, it should be stated in extenuation of his conduct, a recognized part of the mysteries of stickleback courtship. I therefore removed the females, placing them in a tank close by, so that the little gentleman could show off his attire in one tank, while the ladies gazed at him admiringly from the other, without danger of being pestered by his too urgent attentions. After a time one of the females put on her wedding finery, her sides becoming marked with bands of deeper brown; and as she seemed anxious to join the merry little monarch of the other tank, I transferred her thither. He at once became much excited, and looked, if possible, rosier and bluer-eyed than ever. He soon dashed off to the nest to see that all was there in readiness, and passed through it, remaining inside half a minute or so. After having thus prepared his nest for her reception he returned to the female, and swam slowly round and round her, frequently passing in front of her. The gay rogue! He knew that she could not resist those rosy cheeks and that bright blue eye. Nevertheless he found it his duty to dig her several times in the ribs, and was clearly somewhat annoyed that she delayed so long to come to his nest. Unfortunately I was then called away from my room, so that I did not on this occasion see her pass through the nest and lay her eggs there." For further particulars regarding the home-life of this and other kinds of stickleback, the reader is referred to the delightful book from which the above extract is taken.

The Law of Beauty.—We have just seen that a male fish

may assume courtship colours of brilliant kind, but in some species the attractions are of a more elaborate nature. A good instance among British marine fishes is afforded by the Gemmeous Dragonet or Golden Skulpin (*Callionymus lyra*, fig. 1115), where the female is of a dull brown, and was formerly, under the name of the Sordid Dragonet, considered to be a distinct species. The male, however, is yellow, with spots and stripes of blue, besides which his first dorsal fin is relatively large, and

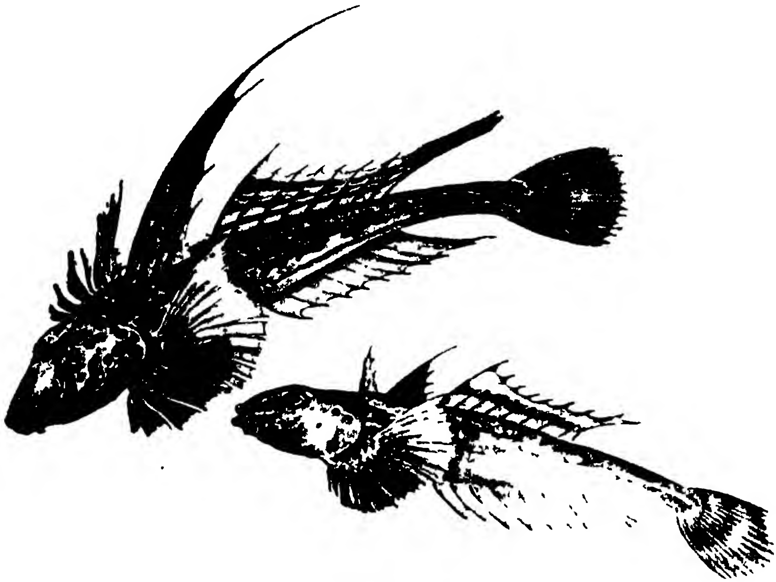


Fig. 1115.—Gemmeous Dragonet (*Callionymus lyra*). Male above, female below

its first ray is drawn out into a long slender filament, which appears to be of the nature of an ornament. Holt has described the courtship of an allied species, the Spangled Dragonet (*C. lineatus*), and says regarding the male that—"its head and body are indescribable mingled harmony of many shades of brown and blue and green, set off with light-blue spots and pearl-coloured stripes; the anterior dorsal fin, which can be erected like a high sail, is golden yellow, studded with many white-edged blue ocelli; the tail fin is a blend of brown and yellow, set with turquoise spots; the belly fin is like dark-blue velvet sown with rows of turquoise; the pelvic fins are like golden-green satin.

fringed with dark blue, and spangled with small turquoise spots; and the pectoral fins are of a delicate lavender-gray, with serried dark-brown spots. The female is but a dish-clout in respect of him." In still another species of Dragonet (*C. carebares*), however, it is the female which is beautiful, and she no doubt takes the lead in courtship. It is interesting to note that Alcock has described an Indian flat fish (*Cynoglossus macrolophus*) in which the male possesses a long crest, owing to the excessive development of the rays at the front end of the dorsal fin, somewhat as in the Dragonets above described.

COURTSHIP AND MATING OF INSECTS (INSECTA)

THE LAW OF BATTLE.—The jaws of some male beetles are of enormous size (fig. 1116), and to these are sometimes added conspicuous horn-like outgrowths from the head or thorax. These features have suggested such names as "stag beetle",

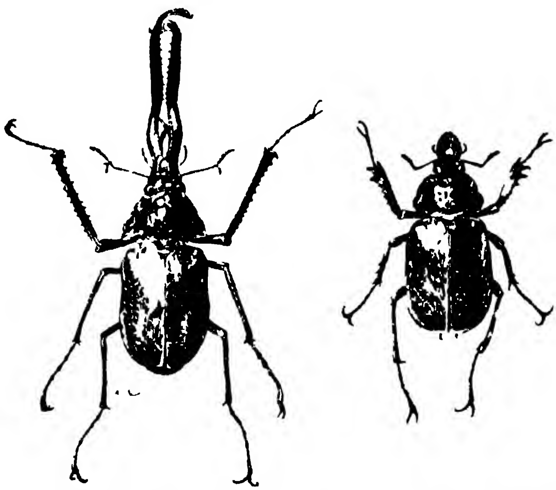


Fig. 1116.—A Tropical Beetle ([illegible]). Male on left, female on right

"rhinoceros beetle", &c. Such structures may possibly be used in fights for the possession of mates, but this has not so far been proved, and the matter must remain unsettled until our knowledge of habits is more complete.

Various male insects have, however, been observed fighting for partners, and Darwin (in *The Descent of Man*) gives appa-

rently well-authenticated instances of this among digging wasp-like forms (*Cerceris*), Saw-Flies, Bees, and even Butterflies.

THE LAW OF BEAUTY.—Male insects, especially Butterflies, are often more beautiful and more conspicuous than individuals of the other sex, but it is necessary here to be cautious in drawing conclusions, for courtship is not the only business of life. That the female should often be in plain attire would often appear to be a protective measure, as it is more important for the welfare of the species that she should escape from enemies than her comparatively useless partner. The same explanation may be given where female butterflies are conspicuous as the result of protective mimicry (see vol. ii, p. 311). This line of argument, however, may easily be carried too far, and the usually brighter colours of the male in insects (and other animals) cannot be satisfactorily explained simply as one of the results of greater energy and activity. In many groups the eyes are complex and highly developed, and that they often minister to a "colour-sense" is generally admitted, the relations between insects and flowers, for example, affording much evidence in this direction (see p. 85). Admitting this, Wallace suggests that his theory of recognition marks (see pp. 132, 140) may account for many of the distinctive colours and markings of insects. In arguing against this view Poulton says (in *The Colours of Animals*)—"that the beauty of the colours and patterns displayed in courtship can never be explained by this principle. For the purposes of recognition, beauty is entirely superfluous and indeed undesirable; strongly-marked and conspicuous differences are alone necessary. But these, which are so well marked in Warning Colours, are not by any means characteristic of those displayed in courtship. If an artist, entirely ignorant of natural history, were asked to arrange all the brightly-coloured butterflies and moths in England in two divisions, the one containing all the beautiful patterns and combinations of colour, the other including the staring, strongly-contrasted colours, and crude patterns, we should find that the latter would contain, with hardly an exception, the species in which independent evidence has shown, or is likely to show, the existence of some unpleasant quality. The former division would contain the colours displayed in courtship and when the insect is on the alert, concealed at other times. The immense difference between the two divisions, the one most pleasing, the other highly repug-

nant to our æsthetic susceptibilities, seems to me to be entirely unexplained if we assume that the colours of both are intended for the purposes of recognition. But these great differences are to be expected if we accept Mr. Darwin's views; for the colours and patterns of the latter division appeal to a vertebrate enemy's sense of what is *conspicuous*, while those of the former appeal to an insect's sense of what is *beautiful*. It is, of course, highly remarkable that our own æsthetic sense should so closely correspond with that of an insect. I believe, however, that it is possible to account for this wonderful unanimity in taste. Our

Fig 1117.—Orange-Tips (*Anthocharis cardamines*) in Centre (male left; female right). Cabbage-Whites (*Pieris brassicæ*) at Sides (male right, female left)

standards of beauty are largely derived from the contemplation of the numerous examples around us, which, strange as it may seem, have been created by the æsthetic preferences of the insect world."

Among our native species the Orange-Tip Butterfly (*Anthocharis cardamines*, fig. 1117) may probably be taken as a good example of courtship coloration. As in most other butterflies, these insects bring their wings togethe when they settle, and are then inconspicuous, as the under surfaces of these organs are protectively coloured, being white with greenish mottlings. This is more particularly true for the female Orange-Tip, which is often found sleeping among the blossoms of Wild Chervil (*Anthriscus sylvestris*), with the colour-scheme of which it harmonizes wonder-

fully. In both sexes the upper sides of the wings are whitish, while the front ones are tipped with black and have a spot in the centre. This can hardly be regarded as a protective arrangement, for it renders the insects conspicuous, though it is not a case of warning coloration; and in the male the effect is greatly heightened by the beautiful orange tips of the fore wings, and since these present this peculiarity on their under as well as on their upper sides, the members of this sex are not so inconspicuous when they settle as are their partners. We can only conclude that the magnificent orange patches are courtship adornment.

It is very interesting to find that there are certain Moths in which the females are degenerate, their eyes among other parts having undergone retrogressive changes. Attractive colours and patterns in the male would be here superfluous, and as a matter of fact the males of such species are commonly dull and plain in appearance.

In some insects the usual rule is reversed, and the female is more beautiful than the male, as in the Cabbage Butterfly (*Pieris brassicae*, fig. 1117) and other Whites, where there are black markings on the fore wings of the former sex. Careful observations have demonstrated that in these species the females are the active wooers, while the males are coy (see appendix, vol. iii, p. 4[illegible]).

A considerable number of male insects proclaim their feelings in an audible manner, as in Grasshoppers and Crickets (see p. 38). Many Beetles too, and some other sorts of insects, such as the Cicadas, are possessed of variously situated and constructed sound-producing organs, of which one of the chief uses appears to be the production of love calls (see vol. i, p. 357, and vol. iii, p. 224). Some male insects are also known which emit a strong musky odour.

That some female insects show a preference for one particular admirer seems to be pretty clearly demonstrated in the case of certain Moths, where a large number of males "assemble" round a female that has just come out of the chrysalis (fig. 1118). The following first-hand evidence on this point is given by Poulton (in *The Colours of Animals*):—"In many species of moths the males 'assemble' round the freshly emerged female, but no special advantage appears to attend an early arrival. The female sits apparently motionless while the little crowd of suitors buzz around her for several minutes. Suddenly, and, as far as one can see,

without any sign from the female, one of the males pairs with her and all the others immediately disappear. In these cases the males do not fight or struggle in any way, and as one watches the ceremony the wonder arises as to how the moment is determined, and why the pairing did not take place before. All the males are evidently most eager to pair, and yet when pairing takes place no opposition is offered by the other males to the successful suitor. Proximity does not decide the point, for long beforehand

Fig. 1118.—"Assembling" of Oak Eggar Moths (*Lasiocampa quercus*). The female is the large pale moth, with simple antennæ, at the top of the cut.

the males often alight close to the female, and brush against her with fluttering wings. In watching this wonderful and complicated courtship one is driven to the conclusion that the female must signify her intention in some way unknown to us, and that it is a point of honour with the males to abide by her decision. I have watched the process exactly as I have described it in a common northern Noctua, the Antler Moth (*Charæas graminis*), and I have seen the same thing among beetles. The fact is well known to entomologists, and as far as the evidence goes, it supports Darwin's theory."

THE FINDING OF MATES. As implied in the preceding para

graphs, an insect may be guided to a suitable mate in several ways. One of the most remarkable is found in the possession of an exceedingly delicate sense of smell by male insects, especially in cases where sight would often be useless. The moths which "assemble" are no doubt a case in point. When an adult female makes her appearance in the world she is quickly attended by a large number of admirers, although immediately before none were to be seen in the immediate vicinity. This fact is well known to collectors, who by the simple device of putting a female that has just left the chrysalis into a little box, with gauze sides,

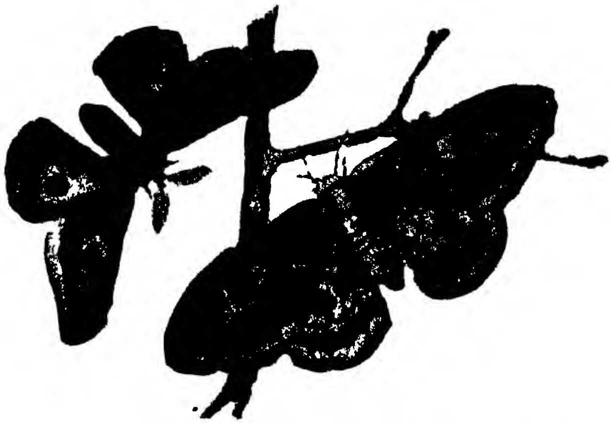


Fig. 1119.—The Emperor Moth (*Saturnia carpini*) Male left, female right

and carrying the same into a suitable locality, are often able to capture large numbers of the corresponding male. In such cases the antennæ of the latter are large and complicated (fig. 1119), no doubt ministering to an unusually acute sense of smell. The mouth-parts of an insect of the kind are often much reduced, his last meal having been taken when he was still a voracious larva. Courtship and mating fill up the brief span of his adult life, and unless a partner be quickly found he is doomed to speedy death in a celibate condition. Hence the extraordinary development of the olfactory organs, to aid him in his quest.

In other cases the visual organs are unusually large, apparently with the same purpose. An instance of the kind is thus described by Carpenter (in *Insects, their Structure and Life*):—"Some male Mayflies are provided with peculiar large frontal eyes, carried on columnar outgrowths of the head, in addition

to normal lateral eyes like those of the females. The reduction of pigment and the presence of a thick layer of homogeneous fluid . . . has led to the conclusion that the special function of these eyes is to discern moving objects in the dusk, to enable the male to secure a mate in the airy twilight dance of the short-lived Mayflies" (fig. 1120).

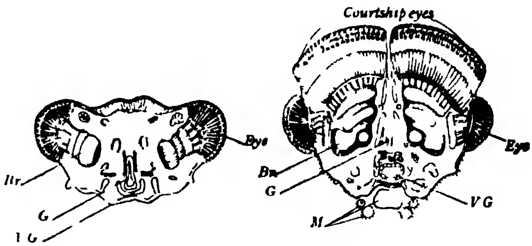


Fig 1120—Horizontal Sections through the Heads of a Male (right and Female (left) Mayfly (*Cloe fuscata*), enlarged *Br* Brain *VG*, ventral ganglion *G*, Gullet *M*, mouth parts

In many of the nocturnal Beetles which are known as Glow-Worms the female is wingless and grub-like, as in our familiar native species (*Lampyris noctiluca*), and practically monopolizes the power of emitting a clear light from peculiar patches of skin along the sides of the body. As the eyes of the male in such cases are well developed, sometimes remarkably so, the object of the arrangement is tolerably clear. In some of the insects of this sort, native to South America, the difference in appearance between the male and female is particularly marked, the latter sex closely resembling the larva (fig. 1121). In Paraguay some of these grub-like females are known as "railway-beetles", being said to exhibit a "danger signal" at either end, and a row of "caution signals" along each side, or, to speak less metaphorically, possessing luminous organs in the positions indicated which respectively emit red and green light. A cynical remark might here be made, as to the appropriateness of such colours in the female sex.

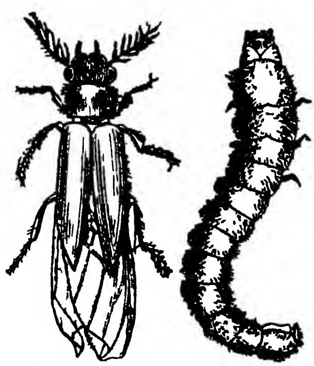


Fig 1121—A South American Glow Worm (*Phengodes Hieronymi*). × 3 Male on left, female on right

There is still, however, much to be learnt as to the meaning of luminous organs in insects, for it appears that in species belonging to the same family as the Glow-Worms, *e.g.* the well-known Fire-Flies (*Luciola*) of South Europe, the light-giving power is more

strongly developed in the males. Nor can it well be deemed as probable that they are here the sought and not the seekers, for we should then expect to find the eyes of the female better developed than those of the opposite sex, but this is not the case.

COURTSHIP AND MATING OF SPIDERS (ARANEIDÆ)

The lot of a male spider is not altogether desirable, for he is much smaller than his prospective partner, who sometimes makes a meal of him. It is scarcely worth while in this case to make separate headings of the Laws of Battle and Beauty, for both may find their application at the same time. Dr. and Mrs. Peckham have investigated this subject as regards species of the family of Hunting Spiders (*Attidæ*). Their observations, some of which are quoted below (from *Papers of the Natural History Society of Wisconsin*, 1889), are intensely interesting, and clearly prove that the females of various species do not mate at random with any swain that offers, often being exceedingly fastidious, and sometimes tragically cruel. The males generally possess special markings and ornaments, which they display in ways that often appear grotesque; they also perform complex evolutions, some of these being rather weird "dances" (fig. 1122), of which one (for *Saitis pulex*) is thus described:—"He saw her as she stood perfectly still, 12 inches away; the glance seemed to excite him, and he moved toward her; when some 4 inches from her he stood still, and then began the most remarkable performances that an amorous male could offer to an admiring female. She eyed him eagerly, changing her position from time to time so that he might be always in view. He, raising his whole body on one side by straightening out the legs, and lowering it on the other by folding the first two pair of legs up and under, leans so far over as to be in danger of losing his balance, which he only maintained by sidling rapidly towards the lowered side. The palpus, too, on this side was turned back to correspond to the direction of the legs nearest it (see fig. 1122). He moved in a semicircle for about 2 inches, and then instantly reversed the position of the legs and circled in the opposite direction, gradually approaching nearer and nearer to the female. Now she dashes towards him, while he, raising his first pair of legs, extends them upward and forward to hold her off, but withal slowly retreats.

Again and again he circles from side to side, she gazing towards him in a softer mood, evidently admiring the grace of his antics. This is repeated until we have counted 111 circles made by the ardent little male. Now he approaches nearer and nearer, and when almost within reach, whirls madly around and around her, she joining and whirling with him in a giddy maze" One feels quite glad to hear that the suit of this particular male was successful. He was decidedly in luck, for we learn that the females

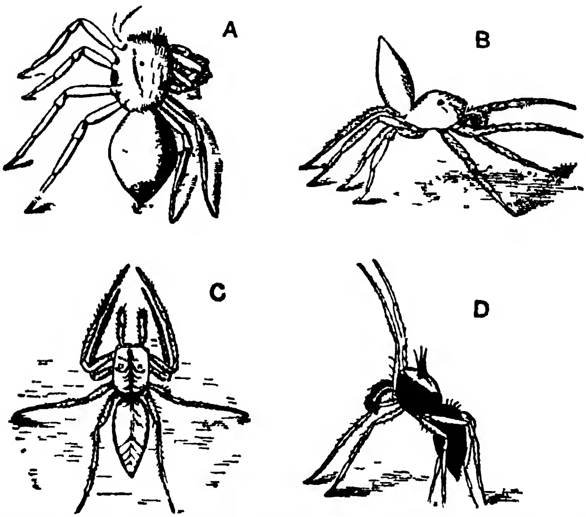


Fig. 1128.—Courtship Attitudes of Male Spiders, enlarged. A *Saitis pulex* dancing. B *Habrocestum splendens* approaching female. C and D Red and black varieties of *Astia vittata* in approaching attitudes.

of his species are very fastidious, and frequently turn admirers away.

A number of males often compete for the good graces of a single female in some of the species observed, in which case the latter takes some time to make up her mind. Competing wooers from time to time interrupt their antics to tussle with one another. Boldness or persistence sometimes wins the day. The male of one species (*Dendryphantes capitatus*) may frisk around for hours displaying his special beauties, until "at last the female, either won by his beauty or worn out by his persistence, accepts his addresses". And in another form (*Hasarius Hoyi*) a male was brave enough to walk up to an evidently displeased female, "when she seized him and seemed to hold him by the head for

a minute, he struggling. At last he freed himself and ran away." Only to come back again, however, for we read that: "This same male after a time courted her successfully". Tragic courtships were also observed, as in the case of a particularly ruthless female (of *Phidippus morsitans*) who behaved thus:—"The two males that we provided for her had offered her only the merest civilities, when she leaped upon them and killed them".

In one remarkable species (*Astia vittata*) the female is red, and there are two kinds of male, red and black respectively, which court in different ways (fig. 1122). When they are rivals, black is invariably the winning colour.

It has been suggested that the small size and great activity of male spiders are adaptations which to some extent reduce the appalling dangers of courtship. In leaving this group the writer ventures to express a hope that many field naturalists may feel moved to observe the habits of common native forms on the lines so successfully followed by Dr. and Mrs. Peckham, in this and other fields (see p. 55). Anything approaching the skill and devotion of these investigators, applied to the study of almost any species, would most assuredly yield a rich harvest of valuable results.

COURTSHIP AND MATING OF CRUSTACEANS
(CRUSTACEA)

Comparatively little is known about the love affairs of the higher members of this group, which deserves far more attention in this matter than has so far been bestowed upon it. It will perhaps suffice here to quote an exceedingly interesting account which is given by Alcock (in *A Naturalist in Indian Seas*) of a little Fiddler Crab (*Gelasimus annulipes*, fig. 1123), which is very abundant on the mud-flats at the mouths of the Godávari and Kistna. The pincers of the female are small, and only used in feeding, but in the male one of them is of great size and bright pink in colour, serving as an ornament and also as a weapon. Alcock thus describes the courtship of these little

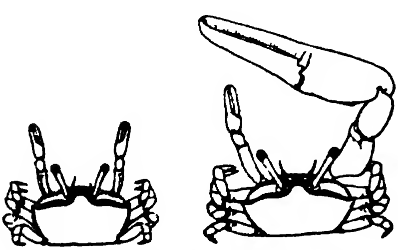


Fig. 1123.—Indian Fiddler Crab (*Gelasimus annulipes*). Female on left, male on right

animals:—" Landing one afternoon in March upon a cheerful mud-flat of the Godávari sea-face, I was bewildered by the sight of a multitude of small pink objects twinkling in the sun, and always, like will-of-the-wisps, disappearing as I came near to them, but flashing brightly on ahead as far as the eye could reach. It was not until I stayed perfectly quiet that I discovered that these twinkling gems were the brandished nippers of a host of males of *Gelasimus annulipes.* By long watching I found out that the little creatures were waving their nippers with a purpose—the purpose apparently being to attract the attention of an occasional infrequent female, who, uncertain, coy, and hard to please, might be seen unconsciously sifting the sand at the mouth of her burrow. If this demure little flirt happened to creep near the burrow of one of the males, then that favoured individual became frantic with excitement dancing round his domain on tiptoe and waving his great cherry hand as if demented. Then, if another male, burning with jealousy, showed a desire to interfere, the two puny little suitors would make savage back-handed swipes at one another, wielding their cumbrous hands as if they had no weight at all.

Some of the Crustaceans possess the power of emitting sounds (see p. 37), possibly to serve as love-calls, and the courtship habits of such species would probably prove interesting.

CHAPTER LXV

ASSOCIATION OF ANIMALS—MESSMATES OR COMMENSALS (COMMENSALISM)

Messmates are organisms of different species which are more or less closely associated, to the benefit of at least one partner in the concern Cases of this sort are grouped under the head of Commensalism Mutualism (*Symbiosis*) is a much more intimate kind of relation between two organisms, to the advantage of both, as already described. The best examples of such Mutualism or Symbiosis involve a partnership for certain cases where plants and animals are thus associated (see p. 75). It is doubtful whether any two kinds of animal live together in this intimate fashion. Parasites are animals which live on or in other animals, at their expense, and to their detriment. Parasitism also includes cases where one organism concerned is a plant (see p. 76).

In a broad sense all the animals which live and feed together in the same place may be regarded as messmates, and the relations between such species may be very complex. It will, however, be well to restrict the term to cases where the connection is of closer and more constant nature, involving the interests of definite species. But it must not be forgotten that this kind of association has no doubt gradually arisen from relations which were originally of more casual kind. So many instances of Commensalism are known that it will only be possible to des ribe a few of the more striking examples.

FISHES (PISCES) AS MESSMATES

Some extraordinary cases have been described where small bony fishes take up their quarters within the digestive organs of lower animals, sallying forth from these peculiar refuges as circumstances dictate. The most familiar instance of this is

afforded by a slender form (*Fierasfer*) living in the gullet of a kind of Sea-Cucumber, which does not appear to gain anything by way of return for its hospitality. Some of the giant sea-anemones living on the Great Barrier Reef of Australia harbour gaily-coloured little fishes belonging to the Perch family, a given species of anemone being the home of a particular species of fish. The fish-guest (*Amphiprion percula*) of one such obliging zoophyte (*Discosoma Kenti*) is orange-red in colour, marked by three cross-bands of pearly white, these and the fins being edged with black. An allied anemone (*D. Haddoni*) entertains a little fish (*A. bicinctus*) which differs from its relative in possessing two bands only, while the black edging is absent.

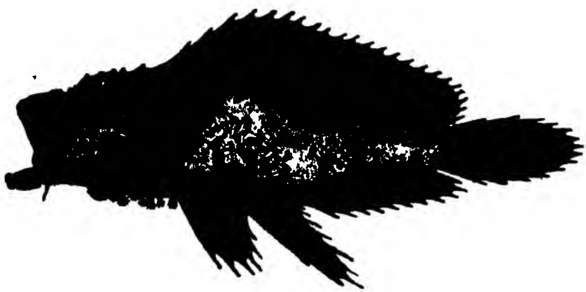


Fig. 1124.—Indian Rock Perch (*Minous inermis*) with Commensal Polypes (*Stylactis minoi*)

The same anemone also extends its hospitality to a red-and-white Prawn (*Palæmon*). In these cases the fishes not only find a secure shelter, the stinging properties of which ward off attack, but also probably filch some of the food of their living homes. On the other hand, it is possible, as suggested by Saville Kent, who has described the associated animals, that the bright tints of the guests serve as "lure colours", enticing animals which serve as food for the anemones.

The relations just described are occasionally reversed, as when a fish serves as a moving home to zoophytes. Alcock describes a Rock Perch (*Minous inermis*, fig. 1124), native to the Indian Ocean, as being always more or less encrusted with small polypes (*Stylactis minoi*), which, being of course carried about from place to place, have a better chance of getting abundant food than if they were attached to a stone or sea-weed. The fish may perhaps derive some protection from the stinging properties of its guests.

MOLLUSCS (MOLLUSCA) AS MESSMATES

A marine snail (*Pleurotoma symbiotes*, fig. 1125), living in the deep water of the Indian Ocean, always has its shell more or less encrusted with colonial sea-anemones (*Epizoanthus*). Both animals are no doubt benefited, for the mollusc is protected, while the anemones are carried about.

A number of small Bivalve Molluscs are associated with burrowing Sea-Urchins or Crustaceans. One such bivalve (*Montacuta ferruginosa*), native to South Devon, lives in the dwelling which a Heart-Urchin (*Echinocardium cordatum*) excavates in muddy sand. The circulation of sea-water which takes place within the burrow (see vol. iii, p. 357) ensures a constant supply of food by which the mollusc benefits. In places where the sand is loose and wet the Heart-Urchin is in the habit of coming to the surface, along which it makes its way, but the lodger is not thereby left behind, for it spins byssus threads that attach it to its partner.

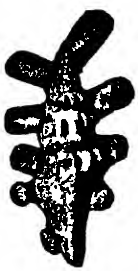


Fig 1125.—An Indian Sea-Snail (*Pleurotoma symbiotes*) with Commensal Sea-Anemones (*Epizoanthus*)

A rare little British Bivalve (*Lepton squamosum*) inhabits the burrow of a prawn-like Crustacean (*Upogebia stellata*), and, having an exceedingly flat shell, does not interfere with the movements of its protector. A similar partnership exists on the coast of Florida between two species related to the preceding, while on the shores of Oregon and California a third association of the sort is more intimate, for here the Lepton attaches itself to the abdomen of the Upogebia. A burrowing Australian prawn (*Axius plectorhynchus*) harbours two species of a kind of bivalve (*Ephippodonta*), which is never found elsewhere. The flatness, so necessary to allow of the restless movements of the prawn, is here produced by the valves of the mollusc opening to their fullest extent. This particular prawn appears to be a specialist in the matter of providing lodgings, for four other bivalves (one species of *Kellia* and three of *Mylitta*) find a commodious home in its burrow, which also contains an orange-coloured sponge. The last possibly serves as a protection to the crustacean, but the arrangement would appear to be quite one-sided so far as the molluscs are concerned.

As with Fishes (see p. 171), Bivalve Molluscs are not always lodgers in the case of partnerships, but may afford shelter to weaker creatures. A well-known instance is that of the little rounded Lodger-Crabs (*Pinnotheridæ*), in which the eyes have undergone great reduction. Among bivalves which provide them with homes may be mentioned Horse-Mussels (*Modiola*), Oysters (*Ostrea*), Pinnas, and Tridacnas, while some crabs of the kind take up their quarters within ascidians or sea-cucumbers. Van Beneden thus speaks of these little lodgers (in *Animal Parasites and Messmates*): -"It is not a taste for voyaging which tempts them, but the desire of having always a secure retreat in every place. The pinnothere is a brigand who causes himself to be followed by the cavern which he inhabits, and which opens only at a well-known watchword. The association redounds to the advantage of both; the remains of food which the pinnothere abandons are seized upon by the mollusc [or, rather, some of its remains may be carried by ciliary action into the mouth of the mollusc]. It is the rich man who instals himself in the dwelling of the poor, and causes him to participate in all the advantages of the position. The pinnotheres are, in our opinion, true messmates. They take their food in the same waters as their fellow-lodger, and the crumbs of the rapacious crabs are doubtless not lost in the mouth of the peaceful mussel. There is no doubt that these little plunderers are good lodgers, and if the mussels furnish them with an excellent hiding-place and a safe lodging, they themselves profit largely by the leavings of the feast which fall from their pincers. Little as they are, these crabs are well furnished with tackle, and advantageously placed to carry on their fishery in every season. Concealed in the bottom of their living dwelling-place (a den which the mussel transports at will) they choose admirably the moment to rush out to the attack, and always fall on their enemy unawares. Some of these pinnotheres live in all seas, and inhabit a great number of bivalve molluscs." The habits of these curious little crabs attracted attention in remote times, and have been the subject of much curious speculation. Stebbing (in *A History of Crustacea*) makes the following remarks upon the ancient views, and discusses the origin of the commensal habit:—"The name *Pinnoteres* means one that watches or guards the *Pinna*, and there can be little doubt that it was the form used by Aristotle

[and not *Pinnotheres*, meaning one that 'hunts the *Pinna*'], seeing that he also speaks of *Pinnophylax*, a word of precisely the same meaning. Not only Aristotle, but many succeeding writers of renown, such as Cicero, Pliny, and seemingly Linnæus himself, accepted the opinion that there was a compact between the mollusc and the crustacean for their mutual benefit. Whenever little fishes swam in between the expanded valves of the mollusc, it was supposed that its companion gave it a little friendly nip, upon which the valves snapped together, the prey was secured, and shared between the confederates. A similar policy was pursued to exclude the intrusion of a dangerous foe. The great antiquity of the belief is attested by the fact that the Egyptians in their hieroglyphics made use of the pinna and crab to symbolize the helplessness of a man without friends. That the belief was untenable was pointed out by many naturalists, from Gesner down to Cuvier, on the ground that molluscs do not feed on little fishes, and that the residence of the crabs within the valves was sufficiently explained by the prevailing softness of the carapace in this family. This indeed applies chiefly to the females, and it is the females that appear to be most frequently found thus domiciled. It is so much the nature of crustaceans to take refuge in any sort of cleft or cranny that the first entrance of the *Pinnotheres* into any sort of bivalve can be easily understood. When the residence proved to be peculiarly secure, the shell of the crab would by degrees lose a hardness that was no longer especially necessary. That the crab may at times be useful to the mollusc seems after all not so very improbable, for at the approach of an enemy so nervous a creature as a crab would no doubt begin to scuttle about, and in this way communicate its terror to its more apathetic companion, which would then naturally close its doors against the danger."

JOINTED-LIMBED ANIMALS (ARTHROPODA) AS MESSMATES

We are here especially concerned with Insects and Crabs, regarding which groups there is a great wealth of material from which to select, so that only a few examples can be here given, supplementing, for the latter animals, what has just been said about Pinnotheres.

INSECTS (INSECTA) AS MESSMATES.—It will be convenient to limit our attention to Bees and Ants, remembering that both belong to an order (Hymenoptera—Membrane-winged Insects) of which the members are distinguished by an extraordinary amount of specialization, associated with mental qualities of no mean order.

Bees as Messmates.—Many species are known of what may be called, for want of a better word, Lodger Bees (*Psithyrus*), each kind of which lives in the nest of some sort of Humble-Bee (*Bombus*). In nearly all such cases the guest closely resembles its entertainer in appearance, and the two dwell together in a perfectly friendly way. The arrangement is of a one-sided nature, for the lodger not only has free quarters, but also makes free use of the provisions stored up by the industrious humble-bee, which, however, is not directly harmed by the association. But as a result of the raids made upon the larder by its lazy lodger, it is not able to rear nearly so many young ones as would otherwise be the case. A nest of a species of Humble-Bee (*Bombus variabilis*), examined by Hoffer in early autumn, contained only a queen and fifteen workers, together with eighteen Lodger-Bees (*Psithyrus campestris*), of which eight were females. But for the strain on the commissariat there would, it was estimated, have been 200 humble-bees in the colony, or even more.

Ants as Messmates.—Occasion has already been taken to note the curious relations which exist between Ants and Aphides, the latter being fed and tended in return for their services as "cows" (see p. 119). Even more extraordinary are the habits of certain Slave-making Ants, which press other ants into their service, employing them in all the varied duties of the nest. The slavers conduct organized raids from time to time, in order to keep up the number of their dependants, and it must be said that these take very kindly to their enforced labours. A notable European example is afforded by the large Amazon Ant (*Polyergus rufescens*), which enslaves the small Brown Garden Ant (*Formica fusca*). The following graphic account of the matter is given by Newman (in *An Introduction to the History of Insects*), and some of the details are set forth in fig. 1126:—
"The most remarkable fact connected with the history of ants is the propensity possessed by certain species to kidnap the workers of other species, and compel them to labour for the benefit of the

community, thus using them completely as slaves; and, as far as we yet know, the kidnappers are red or pale-coloured ants, and the slaves, like the ill-treated natives of Africa, are of a jet black [or at any rate dark in hue] The time for capturing slaves extends over a period of about ten weeks, and never commences till the male and female ants are about emerging from the pupa stage, and thus the ruthless marauders never interfere with the continuation of the species; this instinct seems specially provided, for were the slave ants created for no other end than to fill the

Fig. 1126 —Slave Raid of Amazon Ants (*Polyergus rufescens*)

station of slavery to which they appear to be doomed, still even that office must fail were the attacks to be made on their nests before the winged myriads have departed, or are departing, charged with the duty of continuing their kind. When the red ants are about to sally forth on a marauding expedition, they send scouts to ascertain the exact position in which a colony of negroes may be found; these scouts having discovered the object of their search, return to the nest and report their success. Shortly afterwards the army of red ants marches forth, headed by a vanguard, which is perpetually changing; the individuals which constitute it, when thev have advanced a little before the main body, halting, falling into the rear, and being replaced by others; this vanguard consists of eight or ten ants only. When they have arrived near the negro colony, they disperse, wandering through the herbage

and hunting about, as if aware of the propinquity of the object of their search, yet ignorant of its exact position. At last they discover the settlement, and the foremost of the invaders, rushing impetuously to the attack, are met, grappled with, and frequently killed by the negroes on guard; the alarm is quickly communicated to the interior of the nest; the negroes sally forth by thousands, and, the red ants rushing to the rescue, a desperate conflict ensues, which, however, always terminates in the defeat of the negroes, who retire to the innermost recesses of their habitation. Now follows the scene of pillage; the red ants with their powerful mandibles tear open the sides of the negro ant-hill, and rush into the heart of the citadel. In a few minutes each of the invaders emerges, carrying in its mouth the pupa of a worker negro, which it has obtained in spite of the vigilance and valour of its natural guardians. The red ants return in perfect order to their nest, bearing with them their living burdens. On reaching the nest the pupæ appear to be treated precisely as their own, and the workers, when they emerge, perform the various duties of the community with the greatest energy and apparent good-will; they repair the nest, excavate passages, collect food, feed the larvæ, take the pupæ into the sunshine, and perform every office which the welfare of the colony seems to require; in fact, they conduct themselves entirely as if fulfilling their original destination." The Amazon Ants are practically incapable of feeding themselves, being thus almost entirely dependent upon the good offices of their slaves. They are, however, so fierce and warlike that their dominance in the mixed community is easily understood. Far more remarkable is the mode of life of a rare ant (*Anergates atratulus*), native to Central Europe, in which there is no worker caste, but only females and wingless males, both sexes being weak and helpless. Small numbers of them are found associated with numerous workers of a small species (*Tetramorium cæspitum*), by which they and their offspring are tended, and which are vastly their superiors in strength and energy. How the association comes about is unknown, but it has been suggested that a young fertile Anergates female makes her way into a Tetramorium nest, destroys the queen and young, and is accepted by the workers as their nominal sovereign. A more likely view is that such a female enters a Tetramorium nest containing only workers, and it appears that such nests do some-

times occur More observations are necessary in order to settle the question. Lord Avebury makes the following conjectures (in *Ants, Bees, and Wasps*) as to the past history of Anergates: —"We may safely conclude that in distant times their ancestors lived, as so many ants do now, partly by hunting, partly on honey; that by degrees they became bold marauders, and gradually took to keeping slaves; that for a time they maintained their strength and agility, though losing by degrees their real independence, their arts, and even many of their instincts; that gradually even their bodily force dwindled away under the enervating influence to which they had subjected themselves, until they sank to their present degraded condition—weak in body and mind, few in numbers, and apparently nearly extinct, the miserable representatives of far superior ancestors. maintaining a precarious existence as contemptible parasites of their former slaves."

Ants not only keep cattle and slaves, but are also known, in many cases, to entertain quite a number of insect guests, which they feed and otherwise look after, their attentions being probably often rewarded by some sort of sweet substance produced by their visitors, though this does not appear to be invariably the case. Beetles are especially common among such true guests, and many species (as also of other sorts of insect) are to be found nowhere else, being then known as ants'-nest insects (myrmecophilous insects). They often somewhat resemble their entertainers in appearance, and are fully versed in the ways of the nest. The latter point is well illustrated by the way in which they stroke ants that have returned from foraging, to induce them to disgorge some of the honey with which the crop is distended (fig. 1127, A). One very remarkable case has been described in which certain ants (*Lasius*) carry about mites on their bodies, feeding them from time to time, and otherwise treating them with great consideration, though apparently without deriving any corresponding benefit.

Besides the true guests just mentioned, there may be also various sorts of tolerated guest, which the ants treat with more or less indifference. A case in point is afforded by a small ant (*Formicoxenus nitidulus*), which is permitted to live unmolested in the hills of the large Horse-Ant (*Formica rufa*). A somewhat amusing instance is that of a species of Tassel-tail (*Grassiella polypoda*), which maintains itself in the nest of a kind of ant

(*Lasius mixtus*). In fig. 1127, B is represented a little drama which appears to be frequently enacted by the two kinds of insect. One ant is seen in the act of feeding another by squeezing a drop of sweet fluid out of its crop. A tassel-tail is just about to steal this drop, being also prepared to beat a hasty retreat after accomplishing the impudent theft.

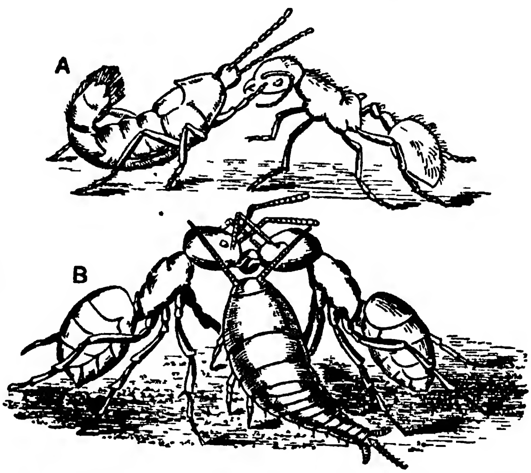


Fig. 1127.—Scenes in Ant Life, enlarged. A, an Ants'-nest Beetle (*Atemeles*) asking to be fed. B, A Tassel-Tail (*Grassiella polypoda*) about to steal a drop of food which one ant is giving to another.

CRABS (BRACHYURA) AS MESSMATES.—Partnerships between Crabs and Sea-Anemones are of common occurrence, the former being benefited by the stinging properties of the Zoophytes, which in their turn are placed under favourable conditions as regards feeding. Such an association between a Buffoon-Crab (*Dorippe facchino*) and an Anemone (*Cancrisocia expansa*) is shown in fig. 1128. An arrangement, differing in detail, has been described in the case of two kinds of crab native to Mauritius, each of which has two anemones as messmates, one fixed to each of the large pincers.

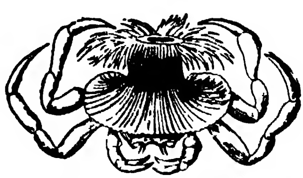


Fig. 1128.—Buffoon Crab (*Dorippe facchino*) with Commensal Sea Anemone (*Cancrisocia expansa*), reduced.

Hermit-Crabs are particularly notable for the partnerships which they contract with Zoophytes, probably because the shells in which they shelter their soft tails afford a convenient surface for attachment. Two British species, for example, *Eupagurus Bernhardus* and *E. Prideauxii*, have as their respective associates two different species of Cloak-Anemone (*Adamsia Rondeletii* and *A. palliata*). Regarding the latter hermit-crab Stebbing (in *A History of Crustacea*) speaks as follows:—"Surmises are sometimes made as to the advantages

which the companions may hope to gain from the alliance. The anemone may obviously obtain a greatly increased range for supplies of food, by the superior locomotive powers of the hermit, and though the weight of both anemone and shell may seem an unnecessary encumbrance to the crustacean, that objection is gradually diminished by the circumstance that the anemone in course of time almost entirely absorbs the shell. On the other hand, the presence of the anemone may be a very valuable protection to the hermit, since numerous fishes are in the habit of swallowing these recluses, shell and all, merely spitting out the shell after they have digested its inmate. But it is most probable that to many fishes an *Adamsia palliata* would be by no means an agreeable morsel, even when flavoured with crab-sauce. It is also not unlikely that the anemone may contribute to the commissariat by throwing out its darts as some swift-gliding shrimp passes by, and thus reducing it to a condition in which it can be captured by the pagurid." In some of the hermit-crabs the shelly dwelling is coated by a hydroid zoophyte (*Hydractinia echinata*), which by its growth is able to enlarge the hermit's home, thus saving him the trouble of looking out for fresh quarters, as in other cases is done from time to time as the exigencies of growth may determine. It is said that when a hermit in partnership with an anemone changes his abode he carefully detaches his messmate from the old domicile and attaches it to the new one.

The messmate of an American hermit (*Eupagurus pubescens*) is a colonial sea-anemone (*Epizoanthus*), which gradually absorbs the protective shell, constituting thereafter an expansible covering, which obviates change of residence. Anderson's Blanket-Crab (*Chlænopagurus Andersoni*, fig. 1129), native to the Indian Ocean, is associated with a similar anemone, and is said never to use a cast-off shell as a refuge. Alcock (in *A Naturalist in Indian Seas*) thus summarizes in an interesting way the salient features of associations of the kind:—"Sea-anemones here [*i.e.* on the Orissa coast], for the most part, were found attached to the shells of hermit-crabs, &c., a case of Hobson's choice sometimes, no doubt, but also sometimes illustrating that happy bond of commensalism, or Platonic union, which is one of the most valuable object-lessons for man's edification that marine zoology affords. When two animals of different grades in the zoological scale live

together in such a fashion that each one assists the other in some definite way, while doing it no manner of harm, they are termed commensals or messmates. For instance, when a hermit-crab and a sea-anemone live together, the hermit-crab, being by nature a very ill-clad and vulnerable animal, acquires by the partnership a thick and easily-adjustable greatcoat, while the sea-anemone, being by nature a hopeless lump of an animal, dependent on chance currents for its food and oxygen, acquires an engine and intelligent engine-driver all in one, which are always carrying it in the way of the necessaries of life; and yet with this mutual assistance there goes absolute independence in all other respects, such as mistresses and servants, who would both be none the worse for a little knowledge of the principles of zoology, never dreamt of."

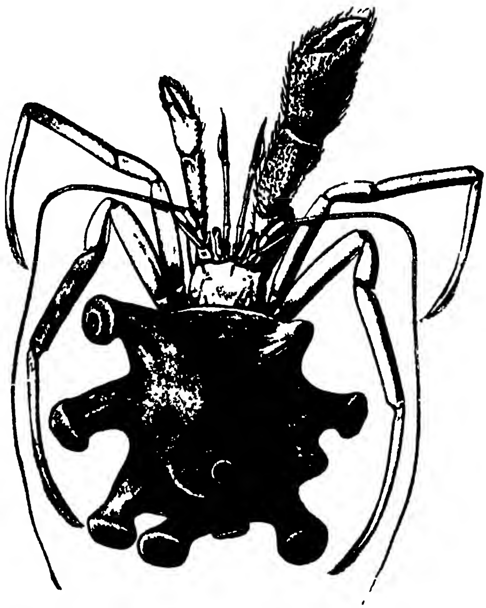


Fig. 1129.—Anderson's Blanket Crab (*Chlænopagurus Andersoni*) with Commensal Sea-Anemones (*Epizoanthus*)

Certain crabs have sponges as messmates, the mutual advantages being much the same as before, it being remembered that sponges are usually avoided by predaceous creatures which appreciate the flavour of crustaceans. In the members of one family of crabs (*Dromidæ*) the last pair of legs are modified in relation to the commensal habit, being small, with more or less hook-like tips, and having shifted somewhat towards the upper side of the body. They are used to hold a sponge or some other passive messmate that serves as a sort of living cape, promoting concealment and protection. In the common Sponge-Crab (*Dromia vulgaris*), as the popular name indicates, this companion is a sponge. So also in a little species (*Cryptodromia pileifera*, fig. 1130) from the coral-reefs

of the Andaman Islands, and in this case the messmate is cap-shaped, and fits very neatly to the back of its active partner.

Fig. 1130.—Under View of an Andaman Sponge-Crab (*Cryptodromia pileifera*) with Commensal Sponge

Hermit-Crabs are also in some instances associated with sponges, one of them (*Eupagurus Cuanensis*) being particularly notable in this respect, for the shell in which it lives is completely overgrown by an orange-coloured species (*Suberites domunculus*), leaving only a small aperture to serve as a front door. As this particular sponge is not only full of sharp spicules, but also disagreeable to both smell and taste, we might expect it to prove a very efficient protection, and Garstang has found by actual experiment that fishes find it extremely repulsive.

SIPHON-WORMS (Gephyrea) AS MESSMATES

Some of these curious worms take up their quarters in empty shells, and in certain cases this has led to a curious kind of commensalism, to some extent teminiscent of what happens in hermit-crabs. For just as anemones attach themselves to the dwellings of hermits, so do certain simple corals affix themselves to the shells appropriated by siphon-worms, afterwards increasing in size so as to conceal these from view, so that in the end we find the base of the coral traversed by a kind of tunnel serving as the home of the worm (fig. 1131). Three different species of coral (*Heteropsammia Michelini*, *Heterocyathus æquicostatus*, and *Stephanoseris Rousseaui*) have been described from the Indian Ocean, each living with a distinct species of a kind of siphon-worm (*Aspidosiphon*). Shipley has carefully examined the species (*A. corallicola*) associated with the first-named coral, and makes the following interesting remarks about the partnership (in *Ceylon Pearl Fishery Report*):—"The whole question of such com-

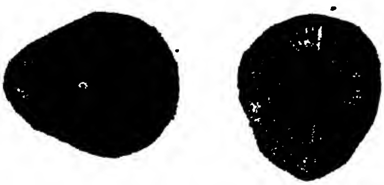


Fig. 1131.—Under (left) and Upper (right) Sides of a Cup-Coral (*Heteropsammia Michelini*), showing opening of the dwelling of its Commensal Siphon-Worm (*Aspidosiphon corallicola*)

mensalism as exists between the *Aspidosiphon* and the coral is an interesting one. Commensalism is usually looked upon as conferring some mutual advantage on the contracting parties, and one or the other of these usually seeks the other out. But in the case in question the mutual advantage is far to seek. It can hardly help the coral to have a large proportion of its base burrowed by a spacious canal, but the fact that the Gephyrean pulls the otherwise immovable coral about may be, and probably is, an advantage to the Cœlenterate. On the other hand, the Gephyrean gains protection and a home more spacious than the Gastropod shell affords. The *Aspidosiphon* can hardly find or attract the larval coral to come to rest on its borrowed shell, and it is unlikely that the larva is especially on the outlook for such shells as are inhabited by Gephyrea. It seems more probable that the *Aspidosiphon* may select for its home a Mollusc shell which already bears a young coral, but the whole matter seems to demand more careful study. It is certainly remarkable that three distinct genera of coral, each with but one species, should be inhabited by three distinct species of *Aspidosiphon*, and that neither commensal has hitherto been found apart from the other." In some cases, at least, there would appear to be a third partner in the concern, for numbers of a kind of minute bivalve mollusc were found closely attached to the outside of the siphon-worms. Regarding them Shipley remarks:—"These were so closely adpressed to the skin of the *Aspidosiphon* as to indent it, appearing as little pearls set in a matrix. The advantage they obtained by taking up such a position is not very evident, but there they were, and as far as one could judge they were, until Professor Herdman dropped them into his collecting-jar, flourishing."

CHAPTER LXVI

ASSOCIATION OF ANIMALS—PARASITES

Parasites live at the expense of larger animals, either using various parts of them as aliment, or robbing them of the food which they have digested. The less modified forms (ectoparasites) attack their "hosts" from the outside, making either an occasional visit, as in the blood-sucking Leeches, or dwelling permanently upon the skin, a condition familiarly illustrated by many of the Fleas. Much greater modification is found among those parasitic animals (endoparasites) which live within their hosts, *e.g.* Flukes and Tape-Worms, and many of these pass through a complicated life-history, in the course of which two or more hosts may be utilized as homes. Many forms are parasites for a part of their lives only, being free-living when young or adult as the case may be, and not infrequently there is a difference between the sexes in this respect, one of them (especially the female) being a parasite and the other not.

The origin of parasitism is not far to seek. It may be regarded in many cases as an outcome of the carnivorous habit. Small animals attacked larger ones which they were unable to kill and devour in a straightforward fashion, so to speak, and the convenience of preying upon a highly nutritious living food-supply, at which it was possible to "cut and come again", naturally led to further evolution of the habit. And it is not difficult to imagine the stages by which external parasites gradually became internal parasites. Sometimes, too, no doubt, parasitism has resulted from the association of messmates (commensalism) in which the partnership was from the first one-sided, or ultimately became so. It would also seem that in many instances the habit possessed by many female animals of seeking out some secure refuge for egg-laying purposes has been the starting-point of parasitic relations. However originated, it is at least certain that the phenomenon of

parasitism is very widely spread, and there is probably no animal which does not unwillingly entertain unwelcome guests that make no return for services rendered. As De Morgan sings (in *The Budget of Paradoxes*):—

> "Great fleas have little fleas upon their backs to bite 'em,
> And little fleas have lesser fleas, and so *ad infinitum*;
> And the great fleas themselves, in turn, have greater fleas to go on,
> Whilst these again have greater still, and greater still, and so on".

The general progress of volution has been from the less to the more specialize as a result of adaptation to increasingly complex surroundings, but to this parasites constitute a striking exception. Free quarters and free rations having been provided for them, they have taken but little part in the active struggle for existence, and well illustrate the principle of Degeneration. They are on the down-grade, adapting themselves to comparatively simple conditions. Hence we find that complex organs of digestion, circulation, respiration, and locomotion, together with nervous system and sense-organs, have undergone more or less reduction in thoroughgoing parasites, though, on the other hand, they have frequently developed special piercing, sucking, and adhesive structures, enabling them to exploit their living food-supply, and to maintain their position. The great danger attending this particular mode of life is constituted by the smallness of the chance of transfer from one host to another. In the more helpless forms this difficulty is often met by the practice of living in two or more different hosts which eat or prey upon one another; the adult egg-producing stage, being the most important, is commonly associated with the strongest and most highly organized of these, the so-called "final host". The biological relations between the successive living refuges is always such as to maintain most surely "the vicious circle of parasitism". Even more important is the immense fecundity of parasites, a necessary provision, for the chances of survival are extremely small. Leuckart calculated, for example, that any one egg of a tape-worm has only one chance in some 83,000,000 of giving rise to an adult.

What is called Brood Parasitism, where an animal shirks the duty of bringing up its own young, will be considered in this section, although it is by no means the same thing as true parasitism.

BIRDS (AVES) AS BROOD-PARASITES

The Common Cuckoo (*Cuculus canorus*), as everyone knows, deposits her just-laid egg in the nest of some small bird, carrying it there in her bill. The proceedings of the young cuckoo, as observed by Mrs. Blackburn, are thus described by Lloyd Morgan (in *Animal Behaviour*):—"One of the most remarkable instincts of young birds is that of the cuckoo, which ejects eggs and nestlings from the home of its foster-parent. Mrs. Hugh Blackburn found a nest which contained two meadow-pipits' eggs, besides that of a cuckoo. On a later visit the pipits were found to be hatched, but not the cuckoo. At the next visit, which was after an interval of forty-eight hours, 'we found the young cuckoo alone in the nest, and both the young pipits lying down the bank, about ten inches from the margin of the nest, but quite lively after being warmed in the hand. They were replaced in the nest beside the cuckoo, which struggled about until it got its back under one of them, when it climbed backwards directly up the open side of the nest, and hitched the pipit from its back on to the edge. It then stood quite upright on its legs, which were straddled wide apart, with the claws firmly fixed half-way down the inside of the nest, among the interlacing fibres of which the nest was woven, and, stretching its wings apart and backwards, it elbowed the pipit fairly over the margin, so far that its struggles took it down the bank instead of back into the nest [fig. 1132]. As it was getting late, and the cuckoo did not immediately set to work on the other nestling, I replaced the ejected one and went home. On returning next day, both nestlings were found dead and cold, out of the nest' (*Birds from Moidart and Elsewhere*)." Similar habits have been described for the Cow-Birds (species of *Molobrus*) of America. One species of these (*M. rufaxillaris*) actually lays its eggs in the nest of a related species (*M. badius*), which is industrious enough to build one for itself. It may further be remarked in passing that some kinds of Cuckoo also construct nests, and bring up their young in the usual way.

Newton, after speaking of the social nesting-habits of certain birds, makes the following suggestions as to the origin of brood-parasitism (in *A Dictionary of Birds*):—"In the strongest contrast to these amiable qualities is the parasitic nature of the Cuckows of the Old World and the Cow-Birds of the New, but

this peculiarity of theirs has already been dwelt upon. Enough to say here that the egg of the parasite is introduced into the nest of the dupe, and after the necessary incubation by the fond fool of a foster-mother the interloper successfully counterfeits the heirs, who perish miserably, victims of his superior strength. The whole process has been often watched, but the reflective naturalist will pause to ask how such a state of things came about, and there is not much to satisfy his enquiry. Certain it is that some birds, whether by mistake or stupidity, do not unfrequently lay their eggs in the nests of others. It is within the knowledge of many that Pheasants' eggs and Partridges' eggs are often laid in the same nest, and it is within the knowledge of the writer that Gulls' eggs have been found in the nests of Eider-Ducks, and *vice versâ*; that a Redstart and a Pied Fly-Catcher, or the latter and a Titmouse, will lay their eggs in the same convenient hole—the forest being rather deficient in such accommodation; that an Owl and a Golden-Eye will resort to the same nest-box, set up by a scheming woodsman for his own advantage; and that the Starling, which constantly dispossesses the Green Woodpecker, sometimes discovers that the rightful heir of the domicile has to be brought up by the intruding tenant. In all such cases it is not possible to say which species is so constituted as to obtain the mastery; but just as it is conceivable that in the course of ages that which was driven from its home might thrive through the fostering of its young by the invader, and thus the abandonment of domestic duties would become a direct gain to the evicted householder, so the bird which, through

Fig 1132.—Young Cuckoo (*Cuculus canorus*) ejecting a Fledgling Meadow-Pipit from the Nest

inadvertence or any other cause, adopted the habit of casually dropping her eggs in a neighbour's nest, might thereby ensure a profitable inheritance for endless generations of her offspring. This much granted, all the rest will follow easily enough, but it must be confessed that this is only a presumption, though a presumption which seems plausible if not likely."

FISHES (Pisces) AS PARASITES

The Lampreys and Hags (*Cyclostomata*) are scaleless, eel-shaped creatures, devoid of jaws, and intermediate in habit between carnivorous forms and external parasites. On the under side of the head is a bell-shaped sucker, the lining of which is thickened into a varying number of sharp horny teeth. At the top of the bell is the true mouth-opening, provided with a projecting "tongue", also tooth-bearing (fig. 1133). By means of the sucker these creatures are able to attach themselves to other fishes, the flesh of which they rasp away, using the tongue for the purpose, this being moved by means of powerful muscles.

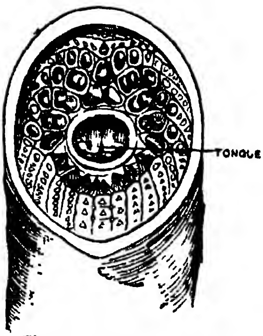


Fig 1133 – Sucker of a Lamprey (*Petromyzon*)

MOLLUSCS (Mollusca) AS PARASITES

Certain Sea-Snails afford the best illustrations of the parasitic habit as occurring among Molluscs. One of the Cap-Shells (*Thyca ectoconcha*, fig. 1134) is an external parasite upon a kind of Star-Fish (*Linckia multiforis*). It will be seen from the illustration that this form is still easily recognizable as a mollusc, though the influence of its particular mode of life is also obvious. The mouth has shifted backwards, and is on the end of a short proboscis, which penetrates into the body of the host, and is surrounded by an adhesive disc, formed by the fusion of parts of the foot with an outgrowth from the head. The characteristic rasping-organ (odontophore) has entirely disappeared, and the pharynx has been converted into a sort of suction-pump by which the juices of the star-fish are drawn in. The body of the same un-

fortunate star-fish may also present a number of rounded swellings in which are lodged parasitic snails of another species (*Stilaster Linckiæ*) that have undergone much further modification, being practically endoparasites in which the proboscis has become very long, while the rest of the body is much smaller in proportion, and the shell has disappeared. Communication with the exterior is still kept up, however, by means of a small hole, in the interests of breathing and the getting rid of waste products. From this case we pass on to degenerate worm-like snails, which are true internal parasites, and have lost most of the typical organs of the group to which they belong, though the study of their life-histories renders no doubt possible as to their classificatory position. Their bodies hang freely into the interiors of their hosts, one end being fixed to the inner side of the body-wall of the same. A degenerate of the kind (*Entocolax Ludwigii*) lives within a species of sea-cucumber (*Myriotrochus Rinkii*), and one still more strongly modified (*Entoconcha mirabilis*) within another creature of the same sort (*Synapta digitata*).

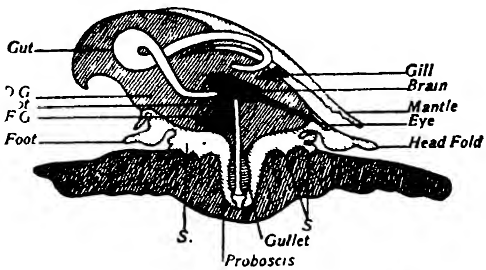


Fig. 1134.—Parasitic Cap-Shell (*Thyca ectoconcha*) attached to the Skin of a Star Fish (*Linckia multiforis*), diagrammatic section. *D G*, Digestive gland, *F G*, foot-ganglion, *S*, *S*, suctorial disc, *ot*, otocyst.

The parasitic habit of the larvæ of Freshwater Mussels has been dealt with elsewhere (see vol. iii, p. 406).

INSECTS (INSECTA) AS PARASITES

Innumerable insects have adopted the parasitic habit, either for the whole of their lives or for some particular stage of existence. It will only be possible to give a limited number of examples in illustration of the more interesting kinds of adaptation.

BUGS (HEMIPTERA) AS PARASITES.—The fact that the insects of this order possess piercing and sucking mouth-parts naturally suggests that some of them attack other animals, which is indeed the case, though the majority would appear to devote themselves

to plants. Where, as largely in Water-Bugs, small creatures are selected as victims, these are killed as a result of the feeding operations, and the true carnivorous habit is illustrated. But Bugs which feed on the blood of relatively large animals may be described as external parasites. The most notable example is the wingless Bed Bug (*Cimex lectularius*), which is fortunately a favourite prey of several other insects, including some belonging to the same order (*e.g.* species of Reduvius). The True Lice, which live entirely upon the blood of Mammals, are very possibly to be regarded as minute Bugs, which have lost their wings and become modified in other ways as a result of the parasitic habit. Considering the mode of life, their small size is clearly an advantage, and their remote ancestors were probably larger insects.

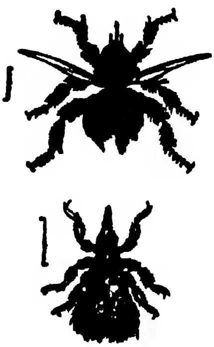


Fig. 1135.—Swallow-Fly (*Stenopteryx hirundinis*) above and Sheep-"Tick" (*Melophagus ovis*) below. The short lines to left show actual length.

Flies (Diptera) as Parasites.—A number of these insects are endowed with mouth-parts adapted for piercing and sucking, and are notable blood-suckers, the habit being commonly restricted to the females. Gnats and Mosquitoes, Midges, Sand-Midges, Breeze-Flies, and Tsetse-Flies, may be cited in illustration. A very interesting series of modifications is found within the limits of one family (*Hippoboscidæ*), which illustrates the reduction of wings resulting from the parasitic mode of life. The feet are provided with strong claws for holding firmly to the animals attacked, and males as well as females are blood-suckers. One of the least modified species is the Forest-Fly (*Hippobosca equina*), which infests horses. Well-developed wings are present, but not much used, as these insects fly unwillingly. Another somewhat similar form (*Lipoptena cervi*) lives on the Red-Deer, and its wings are either shed or bitten off as soon as a host has been secured. The wings of the Swallow-Fly (*Stenopteryx hirundinis*) arc small and narrow, while in the so-called Sheep-"Tick" (*Melophagus ovis*) they are altogether absent (fig. 1135). So also in the Bee-"Louse" (*Braula cæca*), a minute insect that infests bees, and some curious little parasites (species of *Nycteribia*) that have been found among the fur of bats.

Some of the insects of this order live within the bodies of

other animals during the early part of their existence, as, *e.g.*, the Bot-Flies (*Œstridæ*), which are only too well known to the owners of stock. The mouth of the adult is greatly reduced, so that there is no question of blood-sucking, while the larvæ do not devour the living substance of their hosts, but absorb the fluid which surrounds them, and is generally a morbid product resulting from the irritation due to their presence. The Horse-Bot (*Gastrophilus equi*, fig. 1136) lays her eggs upon those parts of the horse's body which are easily reached by the tongue, and the young larvæ, when they hatch out, are thus conveyed to the mouth, whence they make their way to the stomach. The head of the maggot is provided with hooks by which it bores into the lining of that organ. In later stages it becomes ovoid

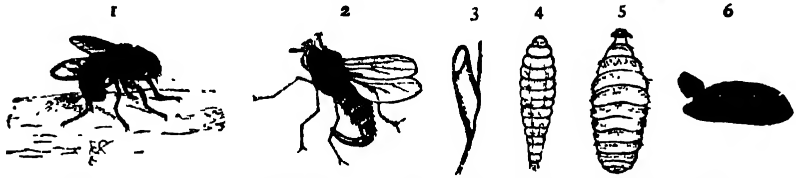


Fig 1136.—Horse-Bot (*Gastrophilus equi*). 1, Male, 2, female, 3, egg (much enlarged) attached to hair, 4, young larva (enlarged), 5, older larva, 6, empty pupa case

in shape, and is known as a "bot". Its powers of adhesion are considerably increased by the presence of circlets of short spines on the body. When a large number of these larvæ are present they set up inflammation, &c., sometimes with fatal results, and they have even been known to bore right through the wall of the stomach. After about nine or ten months the larva looses its hold, and is carried through the digestive organs of the horse to the exterior, where it passes into the motionless pupa stage, from which the adult fly later on emerges.

The eggs of the Sheep-Bot (*Œstrus ovis*) are developed internally, and the female fly deposits the just-born larvæ near the nostrils of the sheep. Thence they pass into the nose, and ultimately into spaces (frontal sinuses) in the bones of the head, where they become "bots". After some nine months' growth these make their way back into the nose, from which they appear to be sneezed out, and pass into the pupa stage. One or two more pests of the kind will be dealt with later, in the section on Animal Foes.

Before leaving the order of Flies, it may be noted that the

wingless blood-sucking Fleas are here included. The modifications which they have undergone have no doubt been in relation to the parasitic habit.

Beetles (Coleoptera) as Parasites and Brood-Parasites.—To this order possibly belongs a family of small insects (*Stylopidæ*) parasitic upon Bees, Wasps and, to some extent, upon certain Bugs. Many zoologists, however, place them in a distinct order (*Strepsiptera*). The adult female is little more than a shapeless bag, living in the abdomen of a bee or other host, with one end projecting externally (fig. 1137). The adult male, on the other hand, is a very active creature, possessing large hind-wings, but only vestiges of fore-wings. His free life is short, three days being the maximum on record, while in some species (of *Xenos*) fifteen to twenty minutes is the limit, though during this brief period extraordinary energy is shown. The numerous eggs are developed internally, hatching out into minute six-legged larvæ, which make their way into the bodies of bee-grubs or the like, though the way in which these hosts are found is in many cases but imperfectly understood. Their presence in the interior of the grubs does not cause death, for they feed upon the fatty substance (fat-body) between the various organs. Having once become parasitic they lose their legs and assume the appearance of minute maggots. Later on, when the bee-grub passes into the pupa stage, the parasitic larva pushes out one end to the exterior, and, if a male, also passes into the pupa stage, but if a female, undergoes comparatively slight modifications. When the adult bees come out of the pupæ the male parasites also emerge to lead their free existence, but the females remain fixed in their hosts. Individual bees harbour but one or a few of these curious parasites; in wasps they may be more numerous.

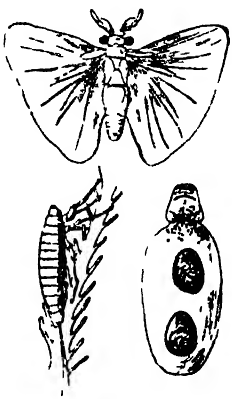


Fig 1137 —A Bee Parasite (*Stylops aterrimus*, enlarged The male is shown above, the female (with two contained embryos below to right, and the larva below to left

The parasitic habits of some of the Oil-Beetles (*Meloidæ*) are both remarkable and highly interesting. Fabre has worked out the life-history of one species (*Sitaris humeralis*, fig. 1138), of which the larvæ feed on the eggs and honey of certain bees

(*Anthophora*) that make underground nests, storing each cell with honey, and then laying an egg therein. In early autumn the female beetle lays her numerous eggs (as many as 2000) near the openings of bees' nests, and these hatch out into minute six-legged larvæ, which hibernate till the following spring. After the winter-sleep is over these little creatures hold on to any hair-clad insects that pass sufficiently near, and are thus carried away. Only those which have by good fortune attached themselves to the right sort of bee have any chance of surviving, and a great many are undoubtedly transported by unsuitable insects, merely to die. Hence in all probability the reason for the production of so many eggs. Some of the successful larvæ unconsciously select female bees as carriers, but most appear to attach themselves to drones, whence they transfer themselves to individuals of the opposite sex. When one of these female bees lays an egg in a honey-filled cell, a predatory larva immediately transfers itself to the egg, and the bee roofs in the cell. To fall into the honey would be fatal to the larva, but it stands firmly on the floating egg, and thus avoids this danger. This scene in the drama lasts for eight days, the larva being busily employed eating up the nutritious contents of the egg. Moulting now takes place, and the once active robber is transformed into a plump grub with breathing-holes (stigmata) placed in the upper part of its body, so that it can float in the honey without fear of suffocation. The sweet food-supply is exhausted in about forty days, by which time it is mid-July, and the grub next becomes a motionless false-pupa, but without shedding its skin, which remains as a dry covering to the body. The further stages in the life-history may follow immediately, but are usually postponed till the following spring, after a long winter-sleep. In either case the false-pupa assumes once more the form of a grub, the skin, however, being retained as a second dry investment. In about two days the grub becomes a true pupa, from which the perfect insect emerges a month later.

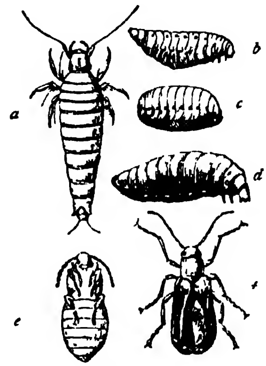


Fig. 1138. Stages of *Sitaris humeralis*, enlarged. *a*, six-legged larva; *b*, floating grub; *c*, false pupa; *d*, second grub stage; *e*, true pupa; *f*, adult beetle.

Some other Oil-Beetles (species of *Meloe*) have much the same

kind of life-history as the form last described, and are parasitic on bees of the same sort. The female beetle does not, however, lay her eggs near a suitable nest, but simply deposits them in the ground. The six-legged larvæ climb up various plants, and commonly lie in wait on or near their flowers, attaching themselves at random to any hairy insects that come near enough. The chances of a given larva reaching a suitable destination are exceedingly small, but as a set-off against this each female beetle lays some 10,000 eggs, which allows for considerable wastage.

MEMBRANE-WINGED INSECTS (HYMENOPTERA) AS PARASITES.—Among the most interesting members of this order in the present connection are the Ichneumon-Flies, and other forms of similar habits, in which the female is provided with a sharp ovipositor,

Fig. 1139.—The Yellow-Legged Ichneumon-Fly (*Microgaster glomeratus*). *a*, Adult. *b*, larva. *c*, dead caterpillar of Cabbage-Butterfly, surrounded by cocoons of the Ichneumon. Size of *a* and *b* indicated by the short lines

by means of which she deposits her eggs within the bodies of the larvæ, pupæ, or even eggs of other insects. In some cases deposition takes place not in, but on or sufficiently near suitable victims. The early stages of Butterflies and Moths are particularly liable to such attacks, and in this way the ravages of many of our familiar agricultural and garden pests are kept within bounds. Some of these parasites are in turn similarly attacked by insects not distantly related to them, a case of the biter bit. The common Cabbage-Butterfly (*Pieris brassicæ*) is subject to the attentions of a number of these forms. By one (*Polynema gracilis*) its eggs are pierced, two others (*Microgaster glomeratus*, fig. 1139, and *Pimpla instigator*) lay their eggs in its caterpillars, and still another two (*Pteromalus puparum* and *P. pontiæ*) attack its chrysalides.

Certain larvæ and pupæ, that live where one would expect them to be quite secure from these parasitic insects, are nevertheless sought out by them, and exposed to the murderous assaults of their brood. One kind of Ichneumon-Fly (*Agriotypus armatus*) boldly plunges into water, and lays her eggs in the

larvæ of caddis-moths. Others (species of *Rhyssa* and *Thalessa*, fig. 1140) possess powerful ovipositors three or four inches long, with which they penetrate trees tunnelled by the larvæ of wood-wasps (*Siricidæ*). The grubs which hatch out from the eggs of such ichneumons attach themselves as external parasites to the wood-boring larvæ. Fabre has described the even more remarkable habits of another parasitic form (*Leucopsis gigas*), that seeks the nests of the Mason-Bee (*Chalicodoma muraria*), in which a number of cells, each containing a larva, are surrounded by little stones cemented together (see p 53). The parasite thrusts her stout ovipositor through weak spots in this masonry, never failing to reach the contained cells, in each of which she deposits an egg. It is only when such a cell contains a full-grown bee-larva, on the point of becoming a pupa, that the operation attains the desired object. In this case the parasitic grub first wanders round the cell to destroy any other eggs that may have been there deposited, and then attaches itself to the bee-larva, the juices of which nourish it for two or three weeks. Next follows a quiescent period of ten or eleven months, after which the larva becomes a pupa, from which the perfect insect soon emerges.

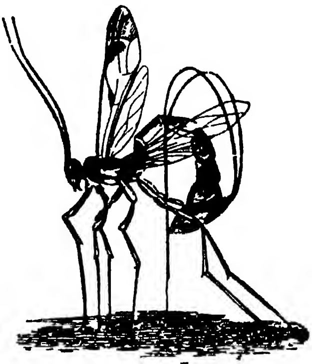


Fig 1140 A Female Ichneumon Fly (*Thalessa*) using her Ovipositor

SPIDER-LIKE ANIMALS (ARACHNIDA) AS PARASITES

Many of the Ticks and Mites (Acarina) are parasitic upon other animals, and some of them have earned considerable notoriety on this account. Ticks are greedy blood-suckers which lurk on plants, and attach themselves to passing birds or mammals, human beings not excepted (fig. 1141). One of the best-known species is the Dog-Tick (*Ixodes ricinus*). A victim once secured, the tick buries its piercing mouth-parts in the skin, and takes in so much blood that it swells visibly. When satiated it drops off, and digests the meal at leisure.

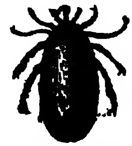


Fig 1141 —A Tick (*Ixodes*), enlarged

Mange- or Itch-Mites exhibit degrees in parasitism. Some of them (*Dermatophagus*) simply devour the loose scales which are constantly being detached from the epidermis, while others (*Dermatocoptes*) suck blood. But the most objectionable (*Sarcoptes*, fig. 1142), those responsible for the unpleasant disease known as "itch", actually burrow in the skin, within which the female lays her eggs, and may therefore be described as true internal parasites. They live on the blood and other juices of their hosts.

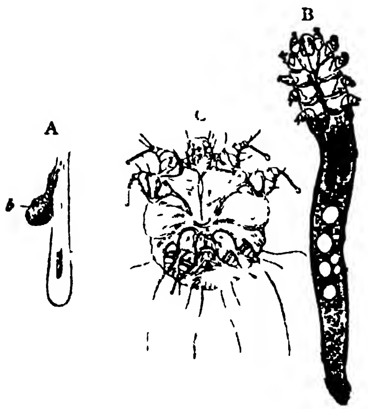


Fig. 1142.—A, Root of hair (a) enlarged, showing a swollen sebaceous gland (b), containing a Hair-Mite (*Simonea folliculorum*); B, A Hair Mite, greatly enlarged; C, An Itch Mite (*Sarcoptes scabei*), greatly enlarged.

A curious little elongated mite (*Simonea folliculorum*, fig. 1142) lives in the little bag-like glands attached to the roots of hair, in which a sort of fatty matter is secreted.

The degenerate Tongue-Worms (*Linguatulida*) which live in the noses of dogs and wolves, are doubtfully classed with the Arachnida (see vol. i, p. 393).

CRUSTACEANS (CRUSTACEA) AS PARASITES

A large number of the lower Crustaceans are parasitic, and some of them have become extremely degenerate as the result of their mode of life, especially in the case of the females. A few examples must suffice.

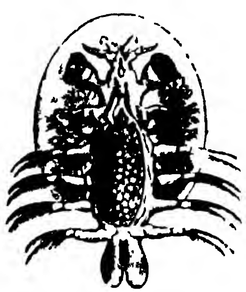


Fig. 1143.—A Carp "Louse" (*Argulus*), enlarged

FORK-FOOTED CRUSTACEA (COPEPODA) AS PARASITES.—Many of the members of this group are found attached to fishes, usually by means of their suctorial mouths. They are popularly, though somewhat inappropriately, known as Fish-"Lice". Among the least modified kinds are those (*Argulus*, fig. 1143) found attached to the skins of carp and sticklebacks, holding on by a couple of suckers

formed by the modification of parts of two limbs. The piercing jaws are enclosed in a sharp beak-like projection.

A larger amount of modification is found in the female parasite (*Achtheres*) depicted in fig. 1144, and which is not infrequently found attached to the gills or living in the throat of the perch. Creatures of the kind also infest a large number of marine fishes. One (*Lernæa*, fig. 1145) is sometimes found attached to the eye of the sprat, and, as it is phosphorescent, the little fishes which harbour these unwelcome guests are known to fishermen as "lantern sprats".

Fig. 1144.—A Perch 'Louse' (*Achtheres percarum*), enlarged

BARNACLES (CIRRIPEDIA) AS PARASITES.—Some of the members of this group have undergone an extraordinary amount of degeneration as a result of parasitism. This is carried to an extreme in a form (*Sacculina*, fig. 1146) that is sometimes found projecting from the under side of the tail of the Shore-Crab (*Carcinus mænas*). Only a professed zoologist would suspect it to be a Crustacean, for in appearance it is simply a rounded bag, which dissection shows to be provided with numerous branching root-like threads that grow through the body of the unfortunate host, extending even to the tips of the limbs. A study of its weird life-history (fig. 1146) definitely proves that it is really a distant relative of its unfortunate host. From the egg hatches out a little larva, of the kind (nauplius) typical for lower Crustaceans (see vol. iii, p. 364). After undergoing several moults it assumes a form not unlike that of a mussel-shrimp, and continues to swim about for three days or more. At the end of this period it seeks a very young crab, and fixes itself by means of a feeler to the soft membrane at the base of one of the bristles on a limb or on the back of its victim. The hinder part of its body is then thrown off bodily, and the organs contained in the remainder fuse together into a soft mass. Around this a membrane is developed, part of which becomes converted into a tube that is pushed into the interior of the crab. Through this the soft substance of the parasite squeezes itself. Within the body of its host it migrates to the region of the intestine, in

Fig. 1145.—Sprat 'Louse' (*Lernæa*) enlarged

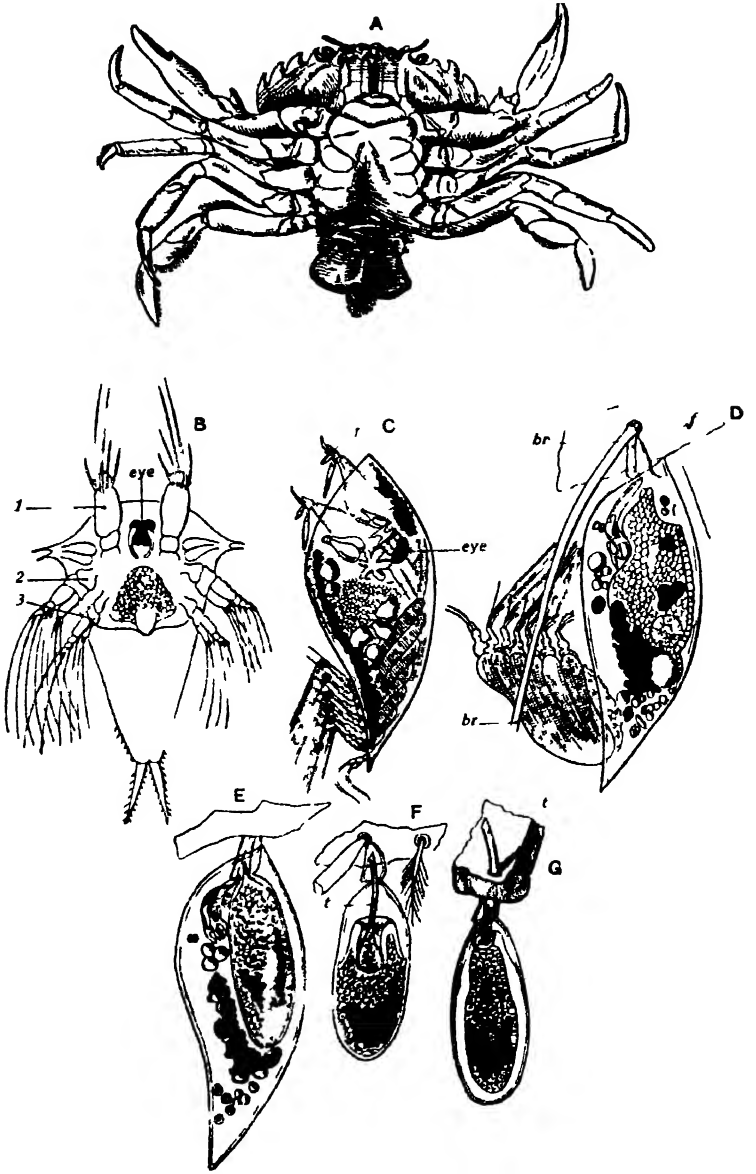


Fig. 114b.—Sacculina. A, Shore Crab (*Carcinus maenas*), with the parasite projecting from the under side of its tail. B–G, Stages in development, greatly enlarged. B, nauplius stage, with two pairs of feelers (1, 2) and one pair of jaws (3). C, mussel shrimp stage, showing modified first pair of feelers (*f*). D, the same, attached by one feeler (*f*) to the base of a crab's bristle (*br*); the hinder part of body is being thrown off. E, F, G, later stages, showing formation of a tube (*t*) through which the soft substance of the parasite passes into the crab.

the neighbourhood of the tail, and root-like threads grow out from it in all directions. Fed by these it grows rapidly, and exerts so much pressure on the muscles and skin which are placed between it and the under side of the tail that they become thinner and thinner. Ultimately, as the final result of this process, the parasite projects to the exterior, its roots, however, remaining inside the crab.

Some of the higher Crustaceans belonging to the group of Slaters (Isopoda) are also parasitic, and have undergone profound modifications.

SEGMENTED WORMS (ANNELIDA) AS PARASITES

We are here concerned with various Bristle-Worms (Chætopoda) and Leeches (Discophora).

BRISTLE-WORMS (CHÆTOPODA) AS PARASITES.—A number of marine worms are external parasites upon hosts of widely different nature, including star-fishes, sea-urchins, sea-cucumbers, corals, and even other annelids. Cases have also been described where one species of marine worm lives parasitically within the body of another species. Much more interesting than these, however, are certain small flattened creatures (e.g. *Myzostoma*, fig. 1147), which live upon, or more rarely within, feather-stars and sea-lilies, sometimes causing gall-like growths that serve as habitations. Since these curious little parasites possess a small number of foot-stumps, each terminating in a pair of bristles, they are probably to be regarded as bristle-worms that have become modified in consequence of their mode of life. And this view is supported by the fact that they begin existence as larvæ which closely resemble those of typical worms of the kind.

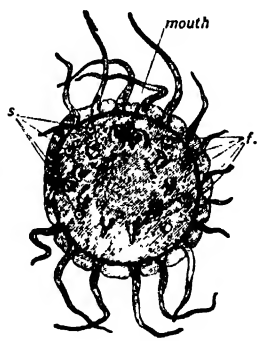


Fig. 1147.—Under Side of *Myzostoma*, enlarged. *s*, Suckers; *f*, foot-stumps.

One large group of Annelids (Few-bristled Worms, *Oligochæta*), of which earth-worms and certain freshwater forms are the typical representatives, includes a small number of species resembling leeches in appearance, as well as in the fact that bristles are entirely absent. They are ectoparasites upon crustaceans, the

Crayfish (*Astacus fluviatilis*), for example, being infested by several of them (species of *Branchiobdella*), which suck its blood and devour its eggs.

Fig. 1148. Fish Leeches (*Piscicola*) attached to the Head of a Carp

LEECHES (DISCOPHORA) AS PARASITES. While some leeches prey upon animals smaller than themselves, others are true external parasites, and the habits of these have been sufficiently described elsewhere (see vol. ii, p. 147). Some of these creatures (e.g. *Piscicola*, fig. 1148) attach themselves to the exterior of fishes, their presence causing great annoyance or even proving fatal.

FLUKES (TREMATODA) AS PARASITES

The flattened unsegmented animals included in this group are, almost without exception, of parasitic habit. They are provided with organs of adhesion, in the form of suckers, and the mouth leads into a muscular pharynx, which serves as a sort of suction-pump by which blood and other substances are taken into the body.

As ectoparasites, flukes are only found upon the bodies of aquatic animals, and in this case three or more suckers are present, since efficient means of holding on are clearly a matter of primary importance. The gills of fishes are particularly liable to such attacks, and it is only natural that this should be so, for their sheltered position, delicate texture, and abundant blood-supply are great advantages, from the parasitic point of view.

We may take as an example a form (*Octobothrium pollachii*, fig. 1149) which lives upon the gills of the pollack, adhering by means of eight stalked suckers. A related species (*O. merlangi*) lives on the whiting, and the herring is infested by a similar parasite, in which, however, the suckers are not stalked. A curious case, where the host is not a fish, is presented by a

minute three-suckered fluke (*Udonella caligorum*), numbers of which attach themselves to the egg-bags of a degenerate crustacean (*Caligus*), living as a parasite upon the gills of the hake.

Aquatic Amphibians do not escape from the attacks of Flukes, a notable instance being afforded by one of these creatures (*Polystomum integerrimum*) which lives, when adult, in the urinary bladder of the frog, and illustrates the transition from external to internal parasitism. It adheres to the lining of the bladder by means of a rounded projection at its hinder end, on which are situated six suckers and many small hooks. The numerous eggs are laid in spring, and pass from the frog's body to the exterior, where they hatch out into minute ciliated larvæ, which actively swim about in search of tadpoles. To understand what happens next it must be remembered that at a certain stage in development a fold grows back from the head of a tadpole, covering the gill-slits, and uniting with the adjacent skin so as to enclose a gill-chamber opening to the exterior by a small hole or spiracle on the left side. The continued existence of the fluke-larva depends upon its finding a tadpole within twenty-four hours, preferably one in the stage described. If successful in this quest it swims into the gill-chamber through the spiracle, and becomes parasitic upon the gills. After living for two months or so in these comfortable quarters a change of residence becomes necessary, for the tadpole is becoming a frog, the gills are disappearing, and the gill-slits are closing up. The larva now makes its way into the pharynx of its host, and passing through gullet, stomach, and intestines, reaches and enters the bladder, where it becomes adult in about three years.

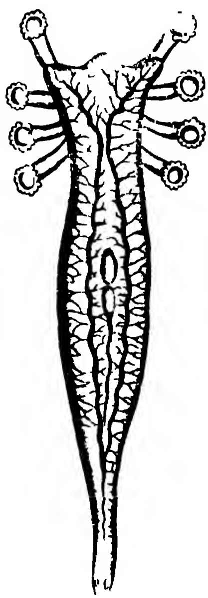


Fig. 1149.—Eight-suckered Pollack Fluke (*Octobothrium pollachii*), enlarged

Mention must here be made of a singular species of many-suckered Fluke (*Diplozoon paradoxum*, fig. 1150) which lays its eggs upon the gills of the minnow. Minute ciliated larvæ hatch out, which perish in from five to six hours unless they find another host of the same kind. In that case, after further growth, they fuse together in pairs, and become X-shaped adults, capable of

producing eggs. The adult is therefore a compound animal, for each stroke of the X was originally a distinct individual, and has a mouth at one end.

A great many Flukes live in the internal organs of various animals, and differ in several important respects from those already described. There is less occasion for adhesive organs, and the usual number of suckers is two, one surrounding the mouth at the front end of the body and the other situated upon the under surface. In some cases the latter is absent. Two or three different kinds of host are infested in the course of the life-history, the reason probably being that unlimited increase in the same sort of host might ultimately lead to its exinction, when a similar fate would overtake the parasite. Although the relations existing between the two or three hosts are such as to favour transfer, the chances are greatly against the survival of a given larva, to meet which contingency immense numbers of small eggs are produced, fewer and correspondingly larger eggs being the rule for external parasites attacking but one kind of host. And, as might be anticipated, the life-history is very complicated.

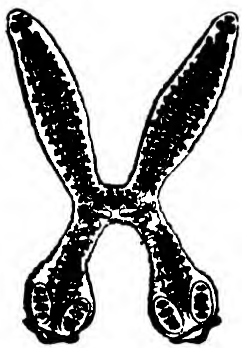


Fig. 1150.—Diplozoön paradoxum

The best-known form is the notorious Liver-Fluke (*Fasciola hepatica*, see vol. i, p. 443), which, when adult, infests the liver of the sheep, producing what is known as "liver rot". To this and other especially injurious species reference will be made later. It will suffice here to describe a form (*Distomum macrostomum*, fig. 1151) in which the life-history is rather simpler, but at the same time of greater interest. This little Fluke, when adult, lives in the intestine of various small birds, such as sparrows, warblers, and tits. Its eggs pass out to the exterior, and many of them get scattered over leaves. If one of them happens to be swallowed by a particular species of small Snail (*Succinea putris*) it hatches out into a minute larva, which bores through the wall of the digestive tube, and penetrates between the organs contained in the body of its host. Being now surrounded by nutritious and easily-absorbed fluid it grows rapidly, becoming converted into a shapeless sac (sporocyst), from which branches are given off in

all directions. Those which lie near the surface of the head, and penetrate into the tentacles, assume a worm-like form, and are brightly coloured with rings of white and green, while the end of each of them is marked with a red spot. These tints are easily seen through the stretched and translucent skin of the snail. The resemblance of these structures to worms is increased by the fact that they expand and contract in a rhythmic way, and they were at one time actually supposed to be a kind of parasitic worm, and received a special name (*Leucochloridium paradoxum*). Attracted by the colours and movement, small birds nip off the tentacles of the snail, the bright-hued tubes of which contain numerous tiny flukes that have developed within them. The fate of these now trembles in the balance, for if they are swallowed by the adult bird itself they are simply digested, but if, on the other hand, they are fed to its nestlings, they are able to develop into adult flukes.

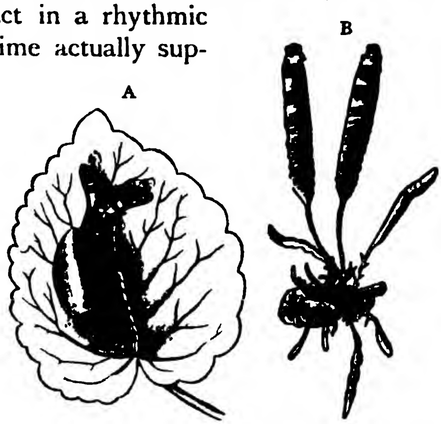


Fig 1151 —*Distomum macrostomum*. A, A Land-Snail (*Succinea putris*) infested by sporocyst, some of the banded worm like branches of which can be seen through skin of head and tentacles B, A sporocyst, enlarged, and showing two worm like branches

TAPE-WORMS (Cestoda) AS PARASITES

Creatures resembling Planarian Worms (see vol. i, p. 445) were probably ancestral to Flukes, and they, in their turn, stand in a similar relation to the degenerate internal parasites known as Tape-Worms. In these the peculiar mode of life has had a still more far-reaching influence, for there are no digestive organs, and the nutriment consists either of the fluids or the already digested food of the animals which play the part of hosts. In either case it is absorbed by the general surface of the parasite.

The simplest kind of Tape-Worm known (*Archigetes Sieboldi*, fig. 1152) is a minute creature, less than one-eighth of an inch long, which lives within the body of the small Red River-Worm (*Tubifex*), and there attains the egg-producing stage, which else-

where is only reached within the digestive tube of a backboned animal. It may possibly be a specialized larva, like the Axolotl (see vol. i, p. 249), but our knowledge is too incomplete to justify such a conclusion.

The best-known Tape-worms consist of a head, provided with organs of adhesion, and passing behind into a series of flat joints (proglottides), in which vast numbers of eggs are produced. The complex life-history of the Common Tape-Worm (*Tænia solium*) has been briefly described elsewhere (see vol. i, p. 441). In the adult condition it lives in the intestine of man, sometimes attaining the length of 9 feet, while in an earlier stage it is found encapsuled in the muscles of the pig, producing the disease known as "measles".

Fig. 1152.—A Simple Tape-Worm (*Archigetes Sieboldii*), greatly enlarged

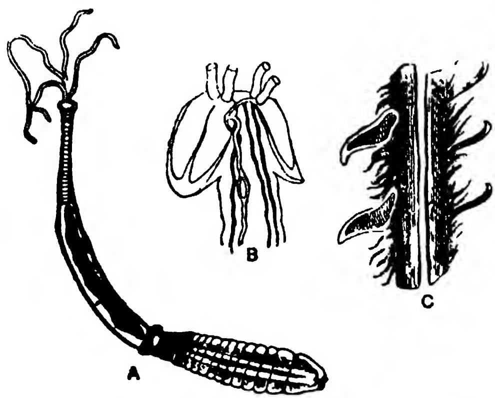


Fig 1153.—A Fish Tape Worm (*Tetrarhynchus*) A, Adult worm, enlarged, showing the four proboscides. B, head of same still further enlarged, showing double suckers, and proboscides slightly protruded C, part of a proboscis, very highly magnified, to show the hooks

In one small kind of Tape-Worm (*Tetrarhynchus*, fig. 1153) the adhesive apparatus on the head is somewhat complex, consisting of two double suckers, and four tubes studded with numerous hooks. When adult it lives in the intestines of fishes of the shark and ray kind (Elasmobranchii). The life-history of one species has been worked out by Herdman and Hornell, and is of particular interest. In this case the host of the adult worm is a large Ray (*Trygon*), which is common in Indian seas. The eggs pass from the body of the fish, and hatch out into minute active larvæ, which perish unless they succeed in entering the shells of

the Pearl-Oyster (*Margaritifera vulgaris*), a well-known bivalve on account of the pearls which it yields. The Gulf of Manaar, in particular, has been the seat of an important pearl-fishery for between two and three thousand years. Successful larvæ bore into the bodies of the oysters, and undergo further development, attaining the size of a small pin's head. One of the mollusc's enemies is the Trigger-Fish (*Balistes*), and if this swallows an infested oyster the tape-worm embryos bore through the wall of the stomach, and become encapsuled in the body of the fish. The trigger-fish in its turn may be devoured by a sting-ray, in which case the young tape-worms become adult. The life-history of this parasite is therefore passed within the bodies of three distinct kinds of animal, the final host being the most powerful, as usual in such cases. It remains to add that many of the tape-worm embryos die while still within the oysters, and, proving a source of irritation, are covered by successive layers of calcareous matter. It is in this way that the best or "orient" pearls are formed.

THREAD-WORMS (Nemathelmia) AS PARASITES

The members of this large group are cylindrical unsegmented worms, most of which are internal parasites in the bodies of animals or plants. They are less degenerate than tape-worms, and the very numerous species differ greatly in respect of the complexity of their life-history, and the hosts infested. One or two of them have already been briefly described (see vol. i, p. 447), and something will be said about others in the section on Animal Foes.

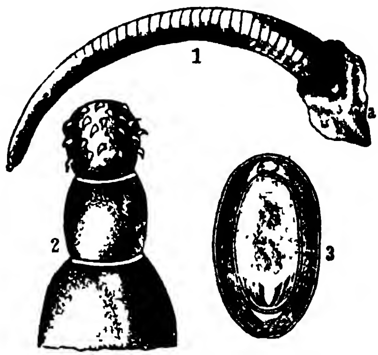


Fig. 1154.—Thorn-headed Worm (*Gigantorhynchus gigas*). 1, A worm attached to the lining (*a*) of a pig's intestine; (2), hooked proboscis of same, enlarged; 3, egg containing an embryo, greatly enlarged

Some curious internal parasites, the Thorn-headed Worms (*Echinorhynchidæ*), are generally regarded as related to the Thread-Worms, and in them the digestive organs are entirely absent. We may take as an example a form (*Gigantorhynchus*

gigas, fig. 1154), which, when adult, lives in the intestine of the pig, maintaining a firm hold by means of a formidable hollow "proboscis", thickly studded with hooks. The eggs pass out of the body of the pig, and some of them are swallowed by beetle-grubs, within which the development is carried on to a certain stage. If an infested grub happens to be eaten by a pig the life-history of the parasite is completed.

ANIMALCULES (PROTOZOA) AS PARASITES

The large group of Gregarines (Sporozoa) includes typical internal parasites, in which the body is surrounded by a firm elastic membrane, through which the body-fluids or digested food of the host are easily absorbed. A well-known form (*Clepsidrina blattarum*, fig. 1155) infests the intestines of the cockroach. The young parasite is worm-like in shape, and its body is divided into three regions, one of which bears hooks, and serves as a means of adhesion to the host. Later on this part is thrown off, and the gregarine lies freely in the intestine, where it absorbs food, and increases considerably in size. The life-history is somewhat peculiar. Two parasites adhere together, and become enclosed in a firm case or cyst, which is passed out of the body of the host. If the surroundings are sufficiently damp the outer part of the cyst swells up into a gelatinous layer, and complex changes go on in the interior. The bodies of the two contained parasites break up into a large number of minute spores, with firm coats, scattered through a kind of net-work. A number of tubes are also formed which turn inside out, and since they convey the spores out of the cyst are termed *sporoducts*. If these spores are swallowed by a young cockroach their firm coats

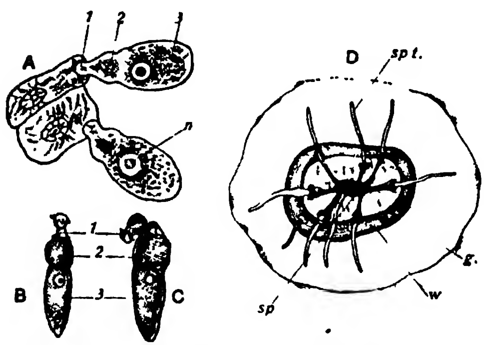


Fig. 1155.—Cockroach Gregarine (*Clepsidrina blattarum*), enlarged to various scales. A, Young gregarines attached to cells of intestine. B and C, later stages lying free within intestine. D, spore cyst in section. 1, 2, 3, Three body regions, of which 1 is thrown off by adult. *n*, nucleus. *g*, gelatinous covering of cyst. *sp*, mass of spores in middle of cyst. *sp t*, spore-tubes. *w*, firm wall of cyst.

are dissolved by the digestive fluids, and the soft protoplasmic contents make their way into the cells which line the intestine, there to develop into worm-like gregarines.

A great number of the Sporozoa are excessively minute parasites living within the bodies of hosts of various kinds, and often giving rise to disease. It has been proved, for example, that malarial fever is due to a blood parasite of the kind introduced by the agency of a Mosquito (*Anopheles*). The complex life-history of this form will be briefly given in the section on ANIMAL FOES.

UTILITARIAN ZOOLOGY

CHAPTER LXVII

ANIMAL FRIENDS—ANIMALS AS A SOURCE OF FOOD—DOMESTICATION—DOMESTICATED MAMMALS

The view taken in this work as to the scope of Utilitarian Zoology has been sufficiently indicated in the Introduction (see vol. i, p. 18), and if by no means free from objection, it may serve to marshal important facts and principles in a fairly orderly manner.

Although the feeding habits of Man differ greatly according to the environment, he may fairly be described as omnivorous (see vol. ii, p. 225), but the proportion of animal food taken increases as we pass from tropical and sub-tropical regions into higher latitudes. The commissariat question has necessarily been a dominant factor in the evolution of human civilization, and this is abundantly evident if we recall the oft-told story of that evolution so far as Western Europe is concerned. In this area, as is generally known, there have been successive Ages of Stone, Bronze, and Iron, names indicating the materials employed in making the chief weapons and implements. During the first of these ages prehistoric man passed through the three most important stages marking the progress of civilization, *i.e.* those of (1) the Hunter and Fisherman, (2) the nomad Herdsman and Flock-Master (pastoral stage), and (3) the Tiller of the Soil (agricultural stage). The first two of these (and of course the third) still find parallels among existing races. In an interesting little book by Jenks (*A History of Politics*) the native Australians are taken as an illustration of the first stage:—" The material side of Australian existence may be best described in a series of negatives. The savages understand neither the cultivation of the land nor the rearing of sheep and cattle. Their only domestic animal

(if 'domestic' it can be called) is the dog. . . . They have no food but the scanty game of the 'bush' or forest, such as the wallaby and the opossum, and the natural products of the earth. . . . It is the custom to speak of the Australians and other savages as living in 'tribes'. But the term is most misleading; for the word 'tribe' always suggests to us the notion of descent from a common ancestor, or at any rate, of close blood relationship. Now there is . . . a most important stage in human progress, in which descent from a common ancestor plays a vital part in social organization. But the Australian 'tribe' does not really play a very important part in savage life, at least on its social side. It appears to be mainly a group of people engaged in hunting together, a co-operative or communal society for the acquisition of food-supply. It would really be better to call it the 'pack'; for it far more resembles a hunting than a social organization. All its members are entitled to a share in the proceeds of the day's chase, and, quite naturally, they camp and live together." To make a complete list of wild animals that minister to the appetite of mankind would be an unnecessary task, but a brief summary is given in the sequel. Savages in particular are often far from fastidious in such matters. Lord Avebury (in *Prehistoric Times*) compiles from various authorities the following somewhat varied bill of fare of these same Australians:—"The food of the Australian savages differs much in different parts of the continent. Speaking generally, it may be said to consist of various roots, fruits, fungi, shell-fish, frogs, snakes, honey, grubs, moths, birds, birds'-eggs, fish, turtles, dogs, kangaroos, and sometimes of seal and whale. The kangeroo, however, forms only an occasional luxury, nor are the natives, so far as I am aware, able to kill whales for themselves, but when one is washed on shore it is a real godsend to them. Fires are immediately lit to give notice of the joyful event. Then they rub themselves all over with blubber, and anoint their favourite wives in the same way; after which they cut down through the blubber to the beef, which they sometimes eat raw, and sometimes broil on pointed sticks. As other natives arrive, they 'fairly eat their way into the whale, and you see them climbing in and about the stinking carcase, choosing titbits'. For days 'they remain by the carcase, rubbed from head to foot with stinking blubber, gorged to repletion with putrid meat —out of temper from indigestion, and therefore engaged in con-

stant frays—suffering from a cutaneous disorder by high feeding—and altogether a disgusting spectacle. There is no sight in the world more revolting than to see a young and gracefully-formed native girl stepping out of the carcase of a putrid whale' (Gray's *Explorations in North-West and Western Australia*). The Australians also mash up bones and suck out the fat contained in them. Like other savages, they are excessively fond of fatty substances.'

To illustrate a predominatingly animal diet we may take the following *menu* of an Esquimaux feast, given by comparatively civilized individuals:—"A factor being invited to a great entertainment with several topping Greenlanders counted the following dishes:—1. Dried herrings. 2. Dried seal's flesh. 3. Boiled ditto. 4. Half-raw and rotten ditto, called mikiak. 5. Boiled willocks [sea-birds]. 6. A piece of a half-rotten whale's tail (this was the dainty dish or haunch of venison to which the guests were properly invited). 7. Dried salmon. 8. Dried reindeer venison. 9. A dessert of crowberries mixed with the chyle out of the maw of a reindeer. 10. The same, enriched with train oil." (Crantz—*History of Greenland.*) It may be added that blood is a favourite Esquimaux drink.

Even among civilized nations fish and molluscs are important articles of food, and it is interesting to know that this was also the case during the Stone Age. Along the shores of Denmark and many other countries, including Britain, are to be found, more or less abundantly, shell-mounds or "kitchen-middens" (Danish *kjökkenmöddings*). the sites of many a prehistoric meal. In Danish mounds the shells of oysters, cockles, mussels, and periwinkles are by far the most abundant, and with them are associated the bones of fishes (herring, dab, eel, &c.), birds, (capercailzie, duck, swan, goose, &c.), and mammals (deer, wild boar, &c). Remains of domesticated animals are entirely absent, except of the dog, and many of the bones have been gnawed by this half-wild attendant at the feasts. Darwin's account (in *A Naturalist's Voyage*) of some of the inhabitants of Tierra del Fuego furnishes a modern parallel to the kind of life led by the prehistoric men of the shell-mounds, except that the latter were probably in better case. He says:—"The inhabitants, living chiefly upon shell-fish, are obliged constantly to change their place of residence; but they return at intervals to

the same spots, as is evident from the piles of old shells, which must often amount to many tons in weight. . . . These poor wretches were stunted in their growth, their hideous faces daubed with white paint, their skins filthy and greasy, their hair entangled, their voices discordant, and their gestures violent. Viewing such men, one can hardly make one's self believe that they are fellow-creatures, and inhabitants of the same world. It is a common subject of conjecture what pleasure in life some of the lower animals can enjoy. How much more reasonably the same question may be asked with respect to these barbarians! At night, five or six human beings, naked, and scarcely protected from the wind and rain of this tempestuous climate, sleep on the wet ground, coiled up like animals. Whenever it is low water, winter or summer, night or day, they must rise to pick shell-fish from the rocks; and the women either dive to collect sea-eggs, or sit patiently in their canoes and, with a baited hair-line without any hook, jerk out little fish. If a seal is killed, or the floating carcase of a putrid whale discovered, it is a feast; and such miserable food is assisted by a few tasteless berries and fungi."

WILD ANIMALS AS A SOURCE OF FOOD

MAMMALS (MAMMALIA).—The large majority of the members of this class, from the Spiny Ant-Eater (*Echidna*) and the Duck-Bill (*Ornithorhynchus*) of Australia up to Man, are, or have been, used as food. As to the two first, it will be seen from the following remarks made by Semon (in *In the Australian Bush*) in regard to Queensland, that even uncivilized races have marked preferences in the matter of diet, when not under stress of famine:—"My blacks were hardly able to furnish me with any information as to the customs of this animal, *i.e.* the Duck-Bill, which they called 'Jungjumore', for they despise its flesh, and consequently never hunt it. In fact, it has an 'ancient and fish-like smell', even after it has been skinned. The blacks showed utter contempt for 'jungjumore , and could hardly be brought to help me in digging up their burrows or to trouble themselves in any way about this, to their minds, useless and inferior creature. The taste for Echidna is quite the reverse, since their regard for it amounts almost to adoration, and they

consider its flesh a first-rate dainty, superior even to beef, which is the greatest compliment they can pay to any food. According to Bennett, the blacks near the Wollondilly and Yas rivers in New South Wales have a different taste, and are very partial to Ornithorhynchus." The *Pouched Mammals* (*Marsupialia*) of Australia have naturally been largely eaten by the natives, and the Kangaroo, at any rate, is decidedly palatable. Semon says of it, in the work just quoted:—"The muscular tail of the kangaroo furnishes a delicious soup, and its flesh is not to be despised".

Hoofed Mammals (*Ungulata*), especially Ruminants, are more important than any others as a source of food, and this is the primary reason why they have been so largely domesticated. Elephants (*Proboscidea*) have been in times past of great importance to the African larder. Sir Samuel Baker remarks (in *Wild Beasts and their Ways*):—"There is no animal that is more persistently pursued than the elephant, as it affords food in wholesale supply to the Africans, who consume its flesh, while the hide is valuable for shields; the fat when boiled is highly esteemed by the natives, and the ivory is of extreme value. No portion of the animal is wasted in Africa, although in Ceylon the elephant is considered worthless, and is allowed to rot uselessly upon the ground where it fell to die." Of *Gnawing Mammals* (*Rodentia*), Hares and Rabbits have always been most esteemed, while *Insect-eating Mammals* (*Insectivora*) are of no particular importance, though gipsies appear to relish the Hedgehog (*Erinaceus*). The related Bats (*Chiroptera*) are not in much favour, but Fruit-bats (*Pteropus*) are eaten by the Malays.

Flesh-eating Mammals (*Carnivora*) inhabiting the land are less useful as a source of food than most other Mammals, though the omnivorous Bears, and to some extent Dogs, must be excepted. It would appear, in some cases at least, to be a matter of prejudice. Wallace found Jaguar steaks good eating, and this suggested to him the following remarks:—"It appears evident to me that the common idea of the food of an animal determining the quality of its meat is quite erroneous. Domestic poultry and pigs are the most unclean animals in their food, yet their flesh is highly esteemed, while field-rats and squirrels, which eat only vegetable food, are in general disrepute." There can be no doubt that the Cat is good eating, and, under numerous

aliases, it is said to figure in the dietary of various European nations. Simmonds (in *Animal Products*) thus speaks of the culinary value of the Lion:—"The flesh of the lion is eaten by the Hottentots; and a tribe of Arabs between Tunis and Algeria, according to Blumenbach, live almost entirely upon it when they can get it. When a lion has been killed and the skin removed, the flesh is divided, and the mothers take each a small piece of the animal's heart and give it their male children to eat in order to render them strong and courageous. They take away as much as possible of the mane, in order to make armlets of it, which are supposed to have the same effect. It would seem from the journal of the Marquess of Hastings, that this superstition as to eating lion's flesh is as strong in India. On the death of a lion it is stated: 'Anxious interest was made with our servants for a bit of the flesh, though it should be the size of a hazel-nut. Every native in the camp, male or female, who was fortunate enough to get a morsel, dressed it and ate it. They have a thorough conviction that the eating a piece of lion's flesh strengthens the constitution incalculably, and is a preservative against many particular distempers. This superstition does not apply to tiger's flesh, though the whiskers and claws of that animal are considered as very potent for bewitching people.' But the flesh of lions has also been eaten with gusto by Europeans, for Madame Bedichon in her work on Algeria states, that at Oran a lion was killed which three days before had eaten a man, and the prefect gave a grand dinner, the principal dish being the lion, which the French gentlemen assembled ate with the greatest relish. More recently still . . . a magnificent quarter of lion, shot in the neighbourhood of Philippeville, Algeria, by M. Constant Cheret, was sent to the Restaurant Magny, Paris, and served up to a party of nineteen guests, who enjoyed with gusto 'Estouffade de lion à la Méridionale' and 'Cœur de lion à la Castellane'." Among aquatic Carnivores the Seals are valuable as a source of food to Esquimaux and other tribes inhabiting cold latitudes.

Of other aquatic Mammals used as food may be mentioned the Manatees (*Manatus*) and Dugongs (*Halicore*), which constitute the order of *Sea-Cows* (*Sirenia*); while reference has already been made (p. 209) to Whales (*Cetacea*) in this connection.

BIRDS (AVES).—Birds are eaten even more indiscriminately than Mammals, though birds of prey and fish-eating forms are avoided. The eggs of some wild birds, *e.g.* Plovers, are esteemed a delicacy. Edible birds'-nests have been mentioned elsewhere (see vol. iii, p. 462).

REPTILES (REPTILIA).—The high reputation of the Green Turtle (*Chelone mydas*) is familiar, and other members of the same order (*Chelonia*) are also eaten in various parts of the world, besides which the eggs of such creatures may also figure as an article of diet.

Some of the larger *Lizards* (*Lacertilia*) are regularly used as articles of food, especially the Iguanas (*Iguanidæ*) of America and the Water-Lizards (*Varanidæ*) of South and South-East Asia.

To a less extent *Crocodiles* and *Alligators* (*Crocodilia*) and *Snakes* (*Ophidia*) serve as a source of food.

AMPHIBIANS (AMPHIBIA).—The only members of the group of importance in this connection are some of the Frogs which are eaten in India and Europe. In the latter case it is the Edible Frog (*Rana esculenta*) that falls a victim.

FISHES (PISCES).—Fishes are and always have been, of great importance as a source of food. A very large number are regularly eaten, and it will be most convenient to deal with these in a special chapter.

MOLLUSCS (MOLLUSCS).—Many kinds of shell-fish are used as food, and some of the more important, *e.g.* the Oyster, will be dealt with separately.

Cuttle-fishes, Squids and Octopods (*Cephalopoda*) are eaten in various parts of the world, particularly by the Chinese and Japanese, while one species (*Eledone*) is a common article of diet in South Europe, nor is it the only one.

Of *Snails and Slugs* (*Gastropoda*) utilized as food by Europeans many examples might be given. The commonest marine form thus employed is probably the Periwinkle (*Littorina*), and after this come Whelk (*Buccinum*), Limpet (*Patella*), and the Ormer or Sea-Ear (*Haliotis*). But there are many more, and in other parts of the world the list is much larger. The marine slug known as the Sea-Hare (*Aplysia*) is eaten in the South Sea Islands.

Land Snails (species of *Helix*) are largely used on the Continent, and to some extent in Great Britain.

Bivalve Molluscs (*Lamellibranchia*) are more important as a source of food than shell-fish of other kinds. Besides Oysters, Cockles, and Mussels there are the esteemed "Clams" of North America (species of *Mya*, *Mactra*, and *Venus*), and Razor-Shells (*Solen*) are also appreciated The last are known in Scotland as "Spout-Fish", on account of the jet of water they squirt out when disturbed On the Ayrshire coast the "hunting of the Spout-Fish" is pursued with great zeal at certain times of the year, a pointed instrument being thrust between the valves. These molluscs burrow obliquely in the sand with great rapidity, and are easily alarmed by the approach of footsteps, so there is considerable room for skill in their capture. Other bivalves commonly used for food are Piddocks (*Pholas*), Date-Shells (*Lithodomus*), and Ark-Shells (*Arca*). But the list might be extended almost indefinitely.

Among *Primitive Molluscs* (*Amphineura*) Cooke (in *The Cambridge Natural History*) says of the Mail-Shells (*Chiton*).—"West Indian negroes eat the large chitons which are abundant on their rocky coasts, cutting off and swallowing raw the fleshy foot, which they call 'beef', and rejecting the viscera"

INSECTS (INSECTA).—Bees (*Apis*) as a source of honey are most prominent here, but they will be noticed in a later section. Next to these, Locusts are perhaps of greatest importance, but Ants and Termites are also eaten The Malays appreciate Cicadas or Tree-Bugs, and by rhythmic hand-clapping are able to lure them down from among the branches. Some of the Scale-Insects (*Coccidæ*) secrete sweet or waxy substances, and regarding one such species Sharp says (in *The Cambridge Natural History*):—"The manna mentioned in the book of Exodus is pretty certainly the honey-dew secreted by *Coccus* (now *Gossyparia*) *mannifera*, which lives on *Tamarix* in many places of the Mediterranean basin. This substance is still called by the Arabs 'man', and is used as food; in its natural state it is a substance very like honey; it is doubtless excreted by the *Coccus*, and is not produced directly by the *Tamarix* as some have supposed." Livingstone mentions a peculiar "kungu cake" eaten by the natives on the shores of Lake Nyassa, and which is made by compressing the bodies of vast numbers of the aquatic larvæ of gnats and related insects.

CENTIPEDES AND MILLIPEDES (MYRIAPODA).—These are men-

tioned here merely as a matter of curious interest. Sinclair remarks as follows (in *The Cambridge Natural History*):—"It is hard to believe that any human being could under any circumstances eat Centipedes, which have been described by one naturalist as 'a disgusting tribe loving the darkness'. Nevertheless, Humboldt informs us that he has seen the Indian children drag out of the earth Centipedes eighteen inches long and more than half an inch wide and devour them. This, I believe, is the only account of human beings using the Myriapoda as food, if we except the accounts of the religious fanatics among the African Arabs, who are said to devour Centipedes alive; though this is not a case of eating for pleasure, for the Scolopendras are devoured in company with leaves of the prickly pear, broken glass, &c., as a test of the unpleasant things that may be eaten under the influence of religious excitement."

CRUSTACEANS (CRUSTACEA).—This group is of obvious importance as a source of food, as the mention of Crab, Lobster, Prawn, and Shrimp is enough to show. A few details will be given in a later section, and it is enough to say here that a very large number of species are eaten in one country or another. One would scarcely expect Barnacles to be used in this way (though they are often mentioned in old accounts of shipwrecks), but certain species are exposed for sale in Spain and South America.

BRISTLE-WORMS (CHÆTOPODA).—The only marine Annelid used to any great extent as human food is the Palolo Worm (*Palolo viridis*) in the Samoa and Fiji islands. The chief facts regarding it are thus summarized by Benham (in *The Cambridge Natural History*):—"The worm . . . . lives in fissures among corals on the reefs, at a depth of about two fathoms. At certain days in October and November they leave the reefs and swim to the shores of the above islands, probably to spawn; and this occurs on two days in each of the above months—the day on which the moon is in her last quarter, and the day before. The natives, who call the worm 'Mbalolo', give the name 'Mbalolo laili (little) to October, and 'Mbalolo levu' (large) to November, thereby indicating the relative abundance of the worms in these two months. The natives eat them either alive or baked, tied up in leaves; and they are esteemed so great a delicacy that presents of them are sent by the chiefs who live on shore

to those living inland." Another worm, of which the habits are much the same, abounds on the shores of Mota Island, in the New Hebrides, and is also eaten.

HEDGEHOG-SKINNED ANIMALS (ECHINODERMATA).—The "roe" of *Sea-Urchins* (*Echinoidea*) was prized as a luxury by the ancient Romans, and is still eaten on the shores of the Adriatic, as well as in other parts of the world. The "sea-eggs" mentioned in the quotation from Darwin's account of the Fuegians given at the beginning of this chapter (p. 211) are animals of the kind. The collection of sea-urchins (chiefly *Hipponoe esculenta*) for food is an important but decaying industry in Barbados, amounting in value to £4000 per annum.

The dried bodies of *Sea-Cucumbers* (*Holothuroidea*) constitute what is commonly known to commerce as *Bêche-de-Mer* or Trepang, an important article of food to the Chinese. The most extensive fishery is on the Great Barrier Reef of Australia, the annual return of which is worth some £23,000 to Queensland. These animals abound in the West Indies, of which the marine resources are not sufficiently developed. One desideratum is a properly-organized trepang fishery.

ZOOPHYTES (CŒLENTERATA).—This group of animals is unimportant as a source of food, but Sea-Anemones (*cul de mulet*) are eaten in France, Sicily, and along the shores of the Adriatic.

DOMESTICATION OF ANIMALS

The domestication of certain animals by man has been one of the most important factors in the evolution of civilization, enabling the prehistoric huntsmen and shore-dwellers to pass into the more civilized pastoral stage, from which gradual transition is easy to the still more civilized agricultural stage.

Although the Dog can claim to be the earliest domesticated animal, our greatest debt is obviously due to various Hoofed Mammals (Ungulata), which include all the larger inhabitants of our farmyards, the Camels of the Old World, and the Llamas of the New, while Elephants belong to an order which is not distantly related. The most important domesticated birds belong to two orders, (1) Ducks and Geese (Anseres), and (2) Game-Birds (Gallinæ), including, more particularly, Fowls (descended from an Indian stock) and Turkeys (natives of North America).

One Insect, too, the Honey-Bee (*Apis mellifica*), has played no mean part in the drama of human civilization, and to this may be added the Silk-Worm (*Bombyx mori*) and the Cochineal Insect (*Coccus cacti*)

The following remarks on the origin of Domestication and some of its results are quoted from Jenks (*A History of Politics*) — "The art of taming wild animals and making them serve the purposes of man, is one of the great discoveries of the world . . But as to the man or men who introduced it we have no knowledge, except through vague and obviously untrustworthy tradition. . . . In all probability the discovery was made independently by many different races, under combinations of favourable circumstances. But if we cannot speak with confidence of names and dates in the matter, we can make certain tolerably shrewd guesses as to the way in which domestication of animals came about. We start with the fact that the most valuable of the world's domestic animals—the sheep, horse, ox, goat, &c.—are known to exist, or to have existed, in a wild state. It is practically impossible to suppose that these wild animals are (except in rare cases) the result of the escape from captivity of tame animals. It follows, therefore, that the start which a pack of savages could obtain in the matter of domestication would depend upon the character of the wild animals in the neighbourhood. For it is fairly obvious by this time that many wild animals are not suitable for taming. Thus, it is hardly possible that the lion, tiger, or bear will ever really become domestic animals, in spite of the fact that their strength and endurance would prove valuable qualities if they could be used. And so some peoples may have remained utterly savage because of the fact that their country does not produce animals capable of domestication. Again, some races, like the Eskimos, appear to have had only the wild ancestors of the dog and the reindeer (fig. 1156), and thus to have been very limited in their opportunities. Other races have been able to tame the sheep, one of the most valuable aids to civilization; others, again, have had the still more valuable ox. But still the question remains—how was the process of domestication discovered? Here, again, we can only proceed by speculation; but a most valuable account of his experiences in Southern Africa (Damara Land), published by the late Sir Francis Galton in the middle of last century, affords us some suggestive hints

(*Narrative of an Explorer in Tropical South Africa*). . . . Two of the most striking features of the savage character are ***recklessness*** and *greed*. Being quite unable to make provision for the future, or even to realize the wants of the future, the savage consumes in disgusting orgies the produce of a successful hunt. A stroke of luck, such as the capture of a big herd of game, simply means an opportunity for gorging. But even the savage capacity for food has its limits; and, in exceptionally good

Fig 1156.—Reindeer (*Rangifer tarandus*)

seasons, there is a superfluity of game. A civilized man would strain every nerve to store the surplus away against future wants. The savage simply wastes it; partly because he knows that meat will not keep, partly because he cannot realize the needs of the future. The 'pemmican' or sun-dried meat of the Red Indian, and his 'caches' or buried hoards, are the limits of the savage capacity for storing up against a rainy day. But if the savage is reckless and greedy, he is often affectionate and playful. If he has had as much food as he can eat, he will amuse himself by playing with his captives instead of killing them. At first, no doubt, there is a good

deal of the cat and the mouse in the relationship; but in time the savage comes positively to love his captives, and even to resist the pangs of hunger rather than kill them. In other words, the earliest domestic animals were *pets*; preserved, not with a view to profit, but for sport or amusement. And it is most important to observe that animals so selected would naturally be the handsomest and finest of the catch, whose appearance would delight the eye. . . . But, of course, feelings of affection would be bound to give way in the long run to feelings of hunger, and then the tame animals would be slaughtered for food. And so it would ultimately dawn on the savage that the keeping of pets was really a profitable business, because it afforded some protection against famine. Gradually it would become more and more common. Finally, the savage would learn by experience that, even without destroying them, his pets could be put to valuable use. Thus the wool of sheep, the hair of goats, the milk of cows, would be to a savage like a gift from an unknown Power. . . . But, when he had got thus far, the savage would have ceased to be a savage; he would have become a *pastoralist*. . . . And then, as all the advantages of the rearing of animals come to be realized, the savage 'pack' gradually changes into a society of shepherds or herdsmen, in which the men are engaged in tending cattle, sheep, or goats, while to the women fall the subordinate offices of spinning the wool, milking the cows and goats, and making the butter and cheese. The men drive the flocks to pasture and water, regulate the breeding, guard the folds against enemies, decide which of the animals shall be killed for food, and break in the beasts of burden." The nomad tribes of the Asiatic steppes, Kirghiz, Kalmucks, &c., are still in the pastoral stage.

A brief account of some of the chief domesticated animals may now appropriately follow.

DOMESTICATED MAMMALS (MAMMALIA) AND THEIR USES

THE DOG (*Canis familiaris*).—It is not likely that the some 180 breeds of Dog which exist at the present day (figs. 1157 and 1158) have all descended from the same wild stock. Various kinds of Wolf, Jackal, and Wild Dog have more probably been domesticated at various times by different races, and the

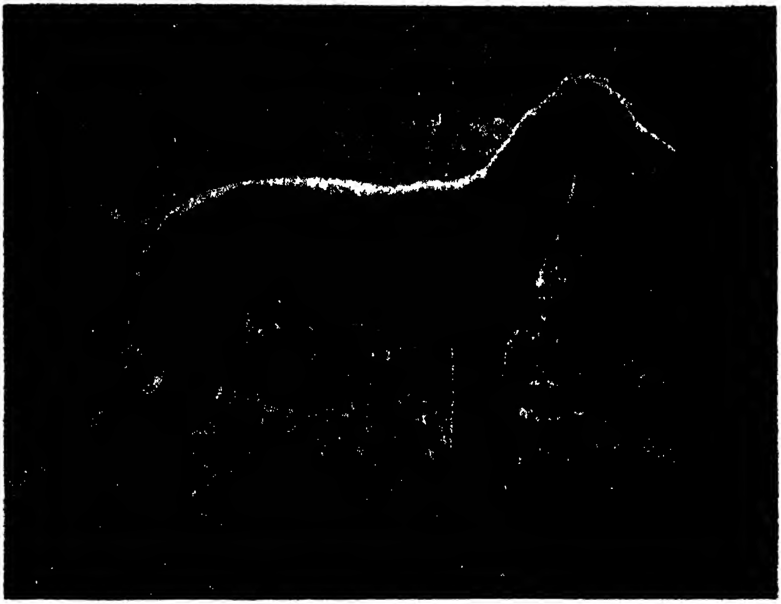


Fig 1157—Greyhound

very wide distribution of the family (*Canidæ*) to which such creatures belong lends probability to this view. We have already

Fig. 1158.—Dachshund

seen (p. 217) that it was the first animal tamed by Man. At a much later period, the monuments of Assyria and Egypt afford

evidence, as Darwin says that (in *Animals and Plants under Domestication*), "four or five thousand years ago, various breeds, viz. pariah dogs, greyhounds, common hounds, mastiffs, house-dogs, lap-dogs, and turnspits, existed, more or less closely resembling our present breeds. But there is not sufficient evidence that any of these ancient dogs belonged to the same identical sub-varieties with our present dogs' (fig. 1159). Although Australia is singularly lacking in higher Mammals, it nevertheless possesses a kind of dog, the Dingo (*Canis dingo*), probably introduced by human agency at a remote period. Friend and companion, guardian of flocks, and protector of the home, no animal has been so closely and so long associated with man as the Dog.

Fig 1159.—Types of Ancient Egyptian Dogs. A, Turnspit, B, House Dog, C, Hunting Dog

The CAT (*Felis domestica*).—Here again we have almost certainly to do with an animal of multiple origin, the Wild Cat (*Felis catus*) of Europe and North Asia being probably not the chief ancestor. On this point Beddard (in *The Cambridge Natural History*) speaks as follows: "The domestic cat is, in fact, regarded as the descendant of the Eastern *F. caffra*, or (perhaps *and*) the closely allied *F. maniculata* (fig. 1160). It is highly probable, however, that after its introduction into this country as a domestic animal it has interbred with the Wild Cat. Many allied species of Cats will interbreed, even two so far apart as the Lion and the Tiger. There are interesting archæological and linguistic reasons for regarding the Domestic Cat as an importation. The legend of Dick Whittington's Cat points to it being a rare and valuable animal, which a tamed *F. catus* would not at that time have been. There was an enactment in Wales against him who should kill the king's Cat, again suggestive of its rarity and consequent value. The very name 'Puss' is a hint of a foreign origin. Some would derive it from Perse, and upon this is based the notion that the

Cat is from Persia. But it seems that Puss is the same as Pasht and Bubastis, showing so far an Egyptian origin for the animal. The ancestral Cats mentioned above are native of Egypt." So far as we know the ancient Egyptians were the first to discover the domestic virtues of this animal, and Herodotus tells us that they treated it with no little consideration (though it scarcely ranked so high as the dog)—"When a fire breaks out a wonderful thing happens to these animals, for the Egyptians, heedless of extinguishing the flames, stand in a line to take care

Fig 1160.—Fallow Cat (*Felis maniculata*)

of the cats; but those creatures, slipping in between the men, or leaping over them, rush into the fire; and when that happens deep grief seizes the Egyptians. If in any house a cat dies naturally, all the inmates shave merely their eyebrows: those in whose house a dog happens to die, shave the whole of their bodies and heads The dead cats are taken to some sacred buildings in Bubastis, where, when embalmed, they are buried. With respect to the dogs, they bury them in sacred repositories, each in his own town."

It is not proposed to refer to Kipling as a zoological authority, but those who have not done so (if such exist) should read the story of domestication in "The Cat that Walked by Himself", as a brilliant *tour de force* of imagination (in *Just So Stories*).

In the same place he neatly hits off the mental difference between Puss and the Dog Binkie:—

"Pussy will rub my knees with her head,
  Pretending she loves me hard,
But the very minute I go to my bed,
  Pussy runs out in the yard.
And there she stays till the morning light,
  So I know it is only pretend,
But *Binkie*, he snores at my feet all night,
  And he is my Firstest Friend!"

Oxen (Bos) and Buffaloes (Bubalus).—The domesticated cattle of various parts of the world are no doubt, like the dogs.

Fig 1161.—Hungarian Oxen

descended from several wild stocks, and some of them would seem to represent a mixture of strains. The two most notable oxen that appear to have been domesticated in Europe during the Newer Stone Age (Neolithic period) were the great Urus (*Bos primigenius*), and a second much smaller species (*B. longifrons*). It is often considered that the wild White Cattle of Chillingham Park are the direct but dwarfed descendants of the former, while the small dark cattle of Wales and the Scottish Highlands can

probably be traced back to the latter. And we have also to take into consideration the European Bison or Aurochs (*Bison Europæus*), a large and savage form now only surviving in parts of Russia, especially in the Lithuanian forest of Bielovege, where it is jealously preserved. This is not the place to consider in detail how far the various breeds of European Oxen (*Bos taurus*) take origin from one or more of the forms just mentioned, or from still others, for the subject is still in the controversial stage. It need only be stated that even in prehistoric times there were

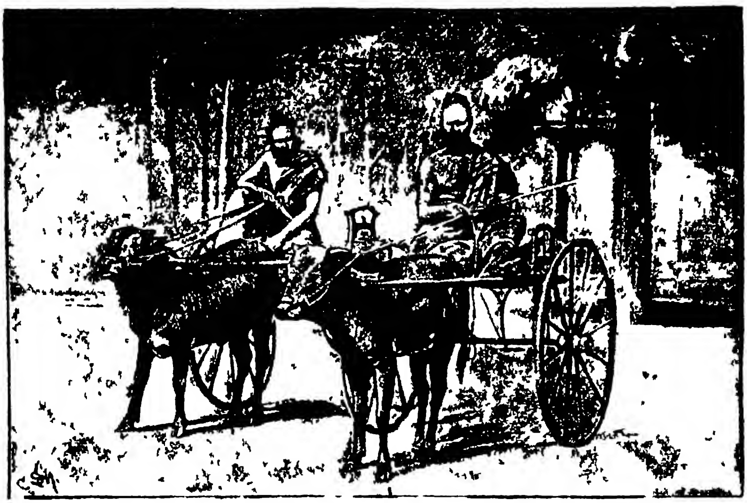


Fig. 1162.—Dwarf Zebus of Ceylon

several domesticated breeds, while now there are a great many. The large pale Hungarian cattle with their formidable horns are amongst the most remarkable (fig. 1161).

Humped Cattle were domesticated by the ancient Egyptians, and we find them still both in Africa and South Asia, under the name of Zebus (*Bos Indicus*, fig. 1162). Their ancestry is doubtful, and it is also a moot point as to whether or no the race of them living in North-East Africa has contributed a strain to certain European breeds. The curious little grunting long-haired Yak (*Bos grunniens*), characteristic of Tibet, is probably quite distinct. Further India possesses another kind of humped ox, the Gayal (*Bos frontalis*).

Differing in many ways from oxen is the tame Buffalo (*Bubalus*

buffelus), ranging from India and Ceylon to South Europe. It is a descendant of the wild Indian Buffalo (*Bubalus arni*).

It is scarcely necessary to remark that oxen, besides serving as an important source of food, are useful in many other ways. In South Africa, for instance, it would be difficult to exaggerate their value for purposes of transport, while in many countries they are used to draw the plough, as, *e.g.*, in Hungary (fig. 1161). Tallow, hoofs, horns, and hides are the most valuable products of the carcase, meat alone excepted. This may be illustrated by the fact that raw hides were imported into this country in 1902 to the value of £2,441 000. It may be added that in June, 1903, the total number of cattle in the United Kingdom amounted to 11 408,560, *i.e.* about 148 head per thousand acres.

THE SHEEP (OVIS ARIES).- Wild Sheep of various species are characteristic of the Northern Hemisphere, and different origins must be sought for the domesticated forms of different areas. Regarding the breeds with which we are familiar in this country there is much difference of opinion, but it is probable that some of them represent a mixture of several different strains. We know that during the Newer Stone Age (Neolithic period) the sheep existed in a tame condition, though it would appear to have been domesticated subsequent to the ox, and the bones that have been found, *e.g.* in connection with some of the Swiss lake-dwellings, indicate a slender and rather goat-like creature. But here, as in the case of our other familiar farm mammals, the question of origin is complicated by the consideration that the invading Neolithic tribes, who drove out the rude hunters and fishermen of the Older Stone Age (Palæolithic period), probably brought domesticated animals with them. If we knew with certainty whence these immigrants came, the problem would be rather less complex, but our knowledge on this point is unfortunately very incomplete. Grave doubt has been cast upon the picturesque view that Central Asia is the "cradle" of the Aryan race, and that the mixed populations of Europe mainly result from successive "waves" of immigration which have radiated from this centre. It is more likely that Neolithic man was of North African stock, and invaded Europe from the south. He certainly at one time inhabited Corsica, Sardinia, Sicily, and South Italy. In view of the possible correctness of the view indicated, it may be well to remember that a wild species of

WILD CATTLE OF CHILLINGHAM

The origin of our domestic breeds of cattle is a question regarding which many conjectures have been made, though the matter is still involved in considerable doubt. They are possibly in part descended from the gigantic prehistoric Wild Ox (*Bos primigenius*) of Western Europe, which survived into historic times and was probably the form known to the ancient Romans by the name of Urus. In Chillingham Park, Northumberland, and elsewhere, wild white cattle are still preserved, and it is considered by some authorities that these are to be regarded as the dwarfed descendants of the Urus. This view, however, cannot be regarded as definitely established.

BRITISH WILD CATTLE (BOS PRIMIGENIUS) IN CHILLINGHAM PARK

sheep, *i.e.* the Barbary Sheep (*Ovis tragelaphus*), is now peculiar to North Africa, and another, the Mouflon or Musimon (*O. musimon*, fig. 1163), is limited to Corsica and Sardinia, though it probably once had a wider distribution. One or both these species have possibly contributed a strain towards the formation of our ordinary tame varieties.

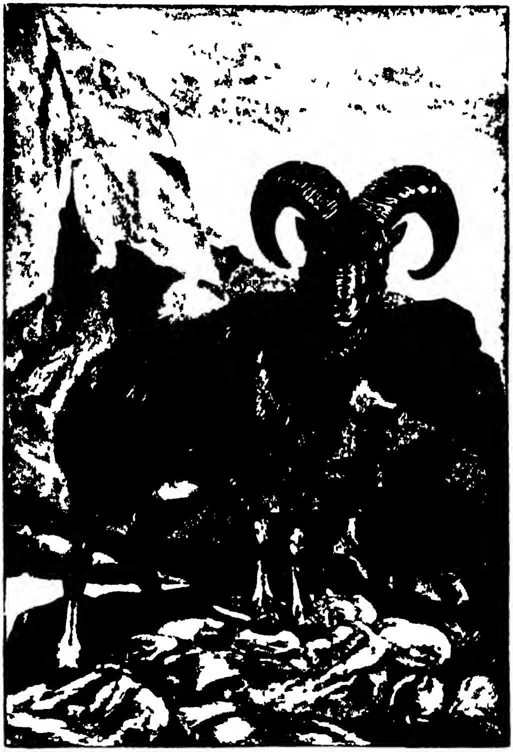
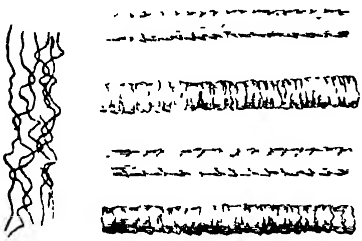


Fig. 1163.—The Mouflon (*Ovis musimon*).

As dwellers among mountains and rocky uplands, Sheep occupy a different place in nature from Oxen, and being close browsers are able to live comfortably on herbage quite unsuitable for horned stock, as may be seen in the barren 'sheep walks' of Central Wales. The practical importance of this is sufficiently obvious. In assessing the value of these animals from the economic stand point, we have to reckon not only with meat and, to a less extent, milk, but also with wool, a material that has played an important part in the history of textile industries. In the colder parts of the globe clothing of some sort ranks as a necessity, which the prehistoric hunter supplied by roughly stitching together the skins of various animals, sinews being used as thread. This kind of clothing is still in vogue among many savage or half-civilized races. Lord Avebury thus speaks (in *Prehistoric Times*) of the Esquimaux in this connection: —"The clothes of the Esquimaux are made from the skins of reindeer, seals, and birds, sewn together with sinews. For needles they

use bones either of birds or fishes; yet with these simple instruments they sew very strongly and well. The outer dress of the men resembles a short greatcoat, with a hood that can be pulled over the head if necessary, and which serves as a substitute for a hat or cap. Their under-garments or shirts are made of bird-skins with the feathers inwards; or of skins with the hair inside; sometimes, however, they wear in addition another shirt made of seal's entrails. Their breeches are either of seal-skin or reindeer-skin, and their stockings of skins from very young animals. The boots are of smooth black dressed seal's leather, and sometimes when at sea they wear a great overcoat of the same material. The dress of the women does not differ much from that of the men."



Fibres of Wool — Fibres of Wool as seen under Microscope

Fig. 1164

For temperate climates skins are far from being a convenient form of clothing, and among the prehistoric races of Europe were gradually replaced by woven fabrics. Coarse materials of the sort made from flax or straw fibres, have been discovered in connection with some of the Swiss lake-dwellings referred to the Stone Age, at a time when tame sheep were few in number. But when this animal became an important domesticated form the possibility of replacing flax, &c., by wool came to be realized. And among the remains of the Bronze Age in Jutland various woollen garments have been found.

The coat of a Mammal typically consists of outer hair, more or less harsh in texture, and soft under-fur, the two being present in different proportions in different cases. The "wool" of Sheep is a specialized kind of under-fur, the individual hairs of which are wavy or crimped, and covered with well-marked overlapping scales, that promote felting together (fig. 1164). Considerable variations exist as to length, fineness, &c., and the fleeces of certain existing breeds are noted for their valuable qualities. In South-west Asia there is a remarkable variety of the domestic form, known as the Flat-Tailed Sheep, in which the tail is enormously large and fat, weighing as much as 40 or 50 lbs. A miniature sledge or cart is often attached to animals of the kind,

for the more convenient carriage of this monstrous appendage. The nomad races of the steppes of Asia possess vast flocks of a related variety, in which, however, the flat tail is very short, and the fat is concentrated on the sides of the rump. The colour of the breed is black, white, or a mixture of the two, and the familiar "Persian lamb" and "astrachan" of commerce are the product of young animals of this breed. The Merino Sheep, originally confined to Spain but now widely distributed, is noted for the length and fineness of its wool.

Fig. 1165. Angora Goats.

The economic importance of wool may be illustrated by the statement that in 1902 our import (worth £20,236,000) amounted to 678 million pounds, and the home production to 136 million pounds. Of these amounts 320 million pounds were exported, while the remainder, *i.e.* 494 million pounds, was worked up for home use.

THE GOAT (CAPRA HIRCUS).—Although this animal does not rank so high as the sheep from the economic stand-point, it possesses considerable value as a source of meat, dairy products, and clothing. We know that it was domesticated by the Swiss lake-dwellers during the Stone Age in rather greater numbers than the sheep. In the same remote period goats, as well as sheep and oxen, were among the tame animals possessed by prehistoric man in Britain.

The most important wild animal from which the domesticated Goat of Europe has taken origin is probably the Grecian Ibex or Bezoar Goat (*Capra ægagrus*), which at the present time ranges from Crete to North-west India. But there is very likely an admixture of one or more other strains.

So far as civilized nations are concerned, the most important products obtained from the Goat are kid-skin, for glove-making, and "mohair", which is the long silky over-hair of certain Asiatic breeds. The chief source of the latter is the well-known Angora Goat, native to Asia Minor, and distinguished by the beauty of its long white silky coat (fig. 1165). The Kashmir Goat, which also ranges into Tibet and the Asiatic steppes, possesses an undercoat of fine soft wool, and it is this which is made into the familiar Kashmir shawls. Large herds of the steppe variety are among the most valuable property of the nomad tribes, not only on account of their skins and wool, but also as a source of meat, milk, butter, and cheese.

THE CAMEL (CAMELUS).—Being eminently adapted to desert conditions the Camel has been a most valuable domestic animal in Asia and Africa from very remote times. There are two species, the one-humped Arabian Camel (*Camelus dromedarius*), which is the familiar kind introduced by the Arabs into Africa, and the two-humped Bactrian Camel (*C. Bactrianus*, fig. 1166) of Central Asia. It is doubtful whether either species exists in the wild condition. Both are represented on the Assyrian monuments. The most important use of Camels is to serve as beasts of burden, a large animal being able to carry 1000 pounds weight or more for a distance of 30 to 35 miles a day. Several breeds exist, and a distinction may be drawn between baggage-camels and racing-camels or dromedaries. The latter are capable of maintaining a pace of from 8 to 10 miles an hour for a considerable part of the day. There are also various crosses between Arabian and Bactrian camels.

Camels are most valuable as beasts of burden, both in peace and war, but they are also an important source of meat and milk, while the thick wool of the Bactrian species is greatly esteemed for textile purposes. The Arabian Camel is by no means limited to Africa and Arabia, for it ranges also from Syria to North-west India, and has been introduced into Italy, Spain, the Canary Islands, North America, and Australia. It is probably of Indian stock.

THE LLAMA (LAMA LAMA) AND ALPACA (L. PACOS).—We know from geological evidence that creatures of the camel kind first came into existence in North America. Thence some of them migrated into the Old World, passing over a land area that once existed in the North Atlantic (or *via* land uniting Alaska and

Fig. 1166.—Kirghiz with Bactrian Camels (*Camelus bactrianus*)

Asia), while others made their way into South America. From the former Camels took origin, and from the latter the cameline forms of South America, with which we are now concerned. All animals of the sort having become extinct in the intervening area, and submergence of the connecting land having isolated the Old World from the New, the group has come to be distributed in a discontinuous manner.

The domesticated camelines of South America are the Llama

and Alpaca, both probably derived from the wild Guanaco (*Lama guanacus*), which now ranges from the mountain regions of Ecuador and Peru to Tierra del Fuego.

The Llama (*Lama lama*), an animal much smaller than the camel, has been an important beast of burden in Peru and Bolivia from ancient times, though now largely replaced by horses, mules, and oxen. Its flesh and wool are also of value. At the time of the Spanish Conquest it is said that some 300,000 llamas were employed in transporting silver from the famous mines of Potosi.

Fig 1167 – Alpacas (*Lama pacos*)

The Alpaca (*L. pacos*, fig. 1167) is somewhat bigger than a large goat, and is bred for the sake of its flesh, and more especially on account of the fine qualities of its fleece, which is distinguished for its softness and elasticity. The fine straight hairs average from 7 to 9 inches in length, and are strong without being coarse, differing in this respect from wool of other kinds.

THE PIG (SUS SCROFA).—While oxen, sheep, and goats are well adapted to the needs of pastoral nomad races, it is quite otherwise with swine, which are notoriously difficult to drive from place to place. Their domestication is, in fact, one mark that their owners have abandoned a wandering life, and entered upon the agricultural stage of civilization, which is a distinct advance upon the pastoral one. We should expect therefore that the prehistoric

THE LLAMA (*Lama lama*)

This animal was domesticated in very remote times by the ancient Peruvians, and even now is an important beast of burden in the high Andes of Peru and Bolivia, though the original breed has been replaced to a great extent by domesticated forms introduced from the Old World. In former times it was used in great numbers for the transport of silver ore from the famous mines of Potosi in Bolivia, more than 13,000 feet above the sea.

The Llama may be described as an American cousin of the Camel, belonging, as it does, to the same group (*Tylopoda*) of Ruminants or Cud-chewers. The earliest known members of this group were, however, native to North America, from which area the stock spread on the one hand into South America, and on the other into the Old World, having since become extinct elsewhere.

LLAMAS (LAMA LAMA) CARRYING GOODS IN THE ANDES

races of the Old World would tame the ox, the sheep, and the goat before turning their attention to the pig, and the evidence of the lake-dwellings of Switzerland favours such a conclusion, for in that area at any rate swine were not domesticated till the Age of Stone had given way to the Age of Bronze. And positive evidence is also available to show that the Swiss lake-dwellers of the latter period cultivated several kinds of grain, and were, in fact, agriculturists of a primitive kind.

Ordinary European Swine are probably not an unmixed race, but the predominant strain in them is derived from the Wild Boar (*Sus scrofa*), which at the present time is widely distributed through Europe, North Africa, West Asia, and Central Asia. It inhabited Britain down to the end of the sixteenth century. The Wild Boar of India, Ceylon, and Further India is probably a variety of the same species. The domesticated pigs of China and Japan would appear to be of entirely different origin.

The uses of the Pig are manifold, and too well known to require detailed notice. As Simmonds says (in *Animal Products*): "It is the animal in which there is the least waste between the dead and living weight, nearly all the carcase being utilized. The blood, the skin, the head, and most of the entrails, which are useless in other animals, serving as food." Leather, bristles, and lard (employed for a great variety of purposes) are the most valuable of the remaining products. In 1902 this country imported about 328,000 tons of bacon and ham, the value of which was £17,285,867 And it was estimated that in June, 1903, the number of swine in the United Kingdom amounted to 4,085,764.

THE HORSE (EQUUS CABALLUS).—Wild Horses were among the animals hunted by prehistoric man in Europe during the Stone Age, as we know from contemporary drawings that have come down to us from the times (Newer Palæolithic period) which immediately preceded the final (or Neolithic) epoch of that age, when the implements and weapons of stone were either neatly chipped or carefully polished. It is remarkable that the men of the Newer Palæolithic period were possessed of considerable artistic power, as is now the case with the Esquimaux, their possible descendants, and they whiled away part of their leisure time by scratching spirited outlines of various wild animals on pieces of bone, ivory, or antler. One such drawing representing two hog-maned horses is depicted in fig. 1168. It would appear,

however, that the Horse was not domesticated in Europe until the Bronze Age, or at least not to any large extent.

At the present time there do not appear to be any truly wild horses of the same species as our domesticated breeds, and the so-called "wild horses" of South America, for example, are simply feral, *i.e.* the descendants of tame animals which have escaped from captivity. There is, however, a small kind of horse (*Equus Przewalskii*, fig. 1169) native to the desert regions of Central Asia, which possibly approaches in some respects to the ancestral stock. The mane is not well developed, and the tail resembles that of a donkey. The greatly specialized limbs of horses and their allies have undoubtedly been evolved as an adaptation to swift progression on plains of desert or steppe nature (see vol. iii,

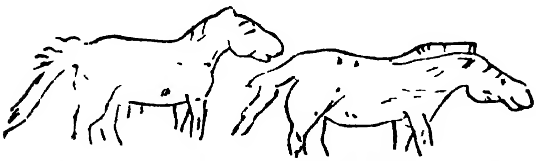


Fig. 1168.—Prehistoric Hog Maned Horses (from Isaac Taylor's *The Origin of the Aryans*, by the courtesy of Mr. Walter Scott)

Fig. 1169.—Przewalsky's Horse (*Equus Przewalskii*)

p. 140), and it is probable that in colour and markings the ancestral forms harmonized more or less with their surroundings. Darwin long ago suggested that the bars and stripes so often present on various parts of the bodies of domesticated horses may be a case of atavism, *i.e.* "reversion" or "throw back" to ancestral characters. Cossar Ewart has greatly elaborated and adduced fresh evidence in support of this view; in his opinion primeval horses were clothed in "striped khaki", with short forelock and hog-mane (as in

Fig. 1170.—Head of "Matopo", Prof. Cossar Ewart's Zebra (*Equus Burchelli*), and of a Norwegian Pony

the prehistoric drawings). Fig. 1170, which Professor Ewart has kindly permitted me to borrow from his book (*The Penycuik Experiments*), shows how the head-stripes possessed by a particular Norwegian pony compare with those on the head of a Zebra, an animal which might almost be described as a striped and hog-maned latter-day horse. The following quotation is taken from the book just mentioned:—"We can only guess as to the colour of the remote ancestor of the horse, but nearly all who have made a special study of the subject have come to the conclusion that the

less remote ancestors were dun-coloured. But it is hardly sufficient to say the ancestors were dun-coloured, for in Norway four shades of dun are recognized, which include nearly every colour from white to black. There are (1) white duns (white and light creams) with white mane and tail; (2) yellow duns with black mane and tail, including creams and light bays; (3) elk duns, frequently approaching in hue bays, chestnuts, and browns, and (4) mouse duns, some of which are nearly black. After a full consideration

Fig. 117. – Arabian Horse.

of the subject, I am inclined to believe the body-colour of the striped ancestral horse of the temperate regions was mainly of a yellowish brown colour. As the descendants extended their range the ground-colour would change, a sand colour probably prevailing in desert areas, a reddish dun in the vicinity of forests, a mouse dun in the far north, a light tint near the tropics, and in the uplands a gray or ash tint." There is a marked resemblance between Norwegian ponies and certain Indian breeds, in view of which it is interesting to notice that according to the traditions of Scandinavia the horse was introduced into that region from the East by the god Odin. But though the body of evidence is on the whole in favour of the view that Central Asia is the old home of

the domesticated species of horse, it must not be forgotten that equines, like camelines, were originally evolved in North America.

The horse, like many other forms domesticated from ancient times, presents a great variety of breeds, produced by artificial selection, and suitable for widely different purposes. Arabians, Clydesdales, and Shetland ponies or "shelties", may be taken as examples (figs. 1171-1173).

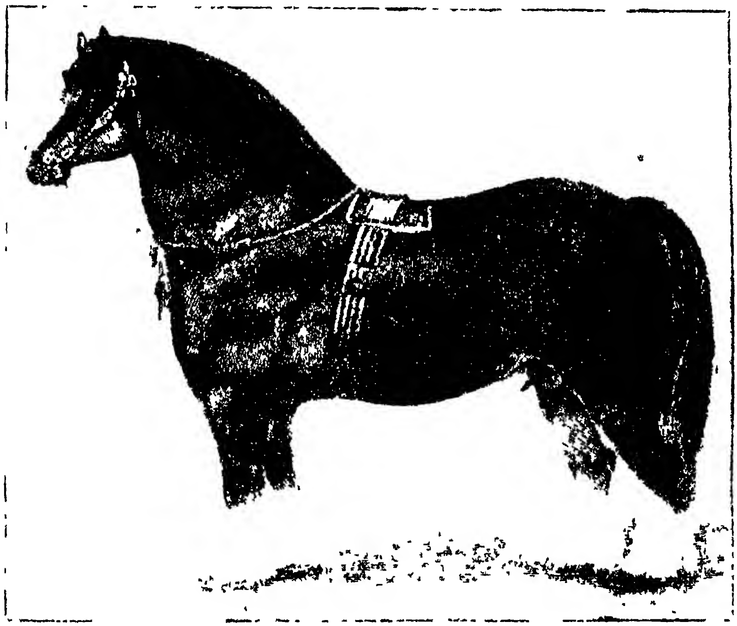


Fig. 1172.—A Clydesdale.

It is unnecessary to dwell upon the important services rendered by the horse to man, alike during peace and in times of war, as a draught animal and for riding purposes. And among our dumb intimates he ranks second only to the dog. The return of live stock of the United Kingdom for June, 1903, included 2,069,859 horses, a modest total compared to over 16½ millions possessed by the United States, and over 22 millions by Russia.

Horse-flesh is by no means unimportant as an article of food, and probably plays a more prominent part in the dietary of Europe than is commonly suspected. The hide is of considerable value, and horse-hair is put to various uses, though the once familiar

hair-cloth, figuring as an eminently respectable if slippery covering for chairs and sofas, has been replaced by cheaper and more attractive materials.

THE ASS (EQUUS ASINUS).—Many of the purposes served by the horse are discharged with considerable efficiency by his

Fig. 1173.—A Shetland Pony.

humbler cousin, a comparatively late comer to Western and Central Europe, though domesticated from a very remote period by the Egyptians and other races (fig. 1174). It would be a mistake to base our judgment of the species upon the ill-fed and

Fig. 1174.—Egyptian Sculpture.

too often cruelly treated donkeys seen in this country, for some of the breeds of South Europe and the East are handsome and even graceful. White asses have long been esteemed, as may be illustrated by an allusion in the Old Testament, "Speak, ye that ride

on white asses, ye that sit in judgment, and walk by the way" (Judges v. 10). The undeserved obloquy from which the modern "moke" suffers is, however, the survival of a very ancient prejudice. Possibly the original source of derision is to be looked for in the shockingly inharmonious voice of this unfortunate creature. The views of the ancient Egyptians on the subject are thus summarized by Houghton (in *Natural History of the Ancients*):—"The ass was sacred to Typho, 'the Evil Being'. According to Plutarch, the Coptites had the custom of throwing an ass down a precipice; and the inhabitants of Busiris and Lycopolis carried their detestation of it so far as never to make use of trumpets, fancying that their sound is similar to the braying of an ass. Even the colour of the unfortunate ass—which, in Egypt, as in ancient Palestine, was of a redder tint than is usual with the domestic ass of England—was looked upon as indicative of the Evil Being, and any unhappy man who was of a ruddy complexion, or had decidedly red hair, was thought to be related to the Evil Being (Typho)."

Several species of wild donkey are native to Asia and Africa. One of the latter, the Nubian Ass (*Equus Africanus* or *tæniopus*), is probably ancestral to the domesticated form. The original stock most likely resembled in colour and markings that from which horses have sprung.

It may conveniently be noted here that the the striped Tiger-Horses or Zebras, of which Africa possesses three indigenous species, are not the wild and intractable creatures once supposed, but are susceptible to domestication. Nor do the zebras of the "fly" districts succumb to the bites of the tsetse-fly, an insect that makes considerable tracts in tropical Africa impossible for horses.

MULES AND ZEBRA-MULES. It is a familiar fact that ordinary mules are crosses or hybrids between horse and ass. On account of their strength, endurance, and sure-footedness they are invaluable beasts of burden in mountainous countries, and play a more important part both in peace and war than is commonly realized in England, where there is considerable prejudice against them. Probably Spain has made more use of them than any other nation, especially in the New World. The importance of the mule in war so far as the British Empire is concerned has been abundantly demonstrated in our African and Indian campaigns, and its value in peace is also considerable.

Unfortunately mules are often vicious, stubborn, and difficult to manage, and probably on this account have not so far been used so much as might be desired in the development of the resources of the mountainous parts of the empire. A partial solution to the problem may perhaps be found in the employment of zebra-mules, *i.e.* crosses between horse and zebra (fig. 1175), which are much more docile than ordinary mules. This step has been advocated by Captain Lugard, Major von Wissmann, and Professor

Fig. 1175.—'Sir John,' [illegible] of Prof. C[illegible] Hybrids [illegible] Matopo, see fig. 11[illegible] dam 'Lunda,' an I[illegible] pony.)

Cossar Ewart, the last of whom makes the following remarks on the subject (in *The Penycuik Experiments*): "I have already referred to the views of Captain Lugard. He writes: 'Some years ago I advocated experiments on taming the zebra, and I especially suggested that an attempt should be made to obtain zebra-mules by horse or donkey mares. Such mules, I believe, would be found excessively hardy, and impervious to the 'fly' and to climatic diseases. . . . I would even go further, and say that their export might prove one of the sources of revenue and wealth in the future; for, as everyone knows, the paucity of mules both for mountain batteries and for transport purposes has long been one of the gravest difficulties in our otherwise

almost perfect Indian Army Corps.' Since this was written much information has been gained as to the dreaded tsetse-fly, but apparently there is extremely little chance of horses being made immune, *i.e.* so treated by inoculation or otherwise that they will be able to survive if once infected by the peculiar minute organism so intimately associated with the all too fatal disease. Further, owing to the destruction of cattle by the rinderpest, the transport difficulties have been increased in Africa, while the frontier wars have increased the demand for mules in India. On the other hand, it has been proved that it is a comparatively simple matter to cross various breeds of mares with a Burchell zebra, and if experts are to be trusted, the hybrids (zebra-mules, as some call them) promise to be as useful and hardy as they are shapely and attractive. The preliminary difficulties having been overcome, it remains for those in authority to ascertain of what special use, if any, zebra hybrids may be in various parts of the Empire, but more especially in Africa and India." Prof. Ewart, in a recent letter (March, 1904), has kindly supplied me with further information.—"Some of the hybrids are constantly being driven in Hamburg. Eight of those I bred are going to the St. Louis Exposition. Apparently a hybrid withstands the tsetse poison better than a zebra which has not been reared in the 'fly' country. Some of the hybrids out of Iceland (inbred) ponies are extremely tractable, and can be used for carrying children."

THE ELEPHANT.—Although both African and Indian Elephants can be tamed, it is only the latter species that has been of very great service to man as a domesticated animal Its considerable intelligence and enormous strength make it useful as a beast of burden and for lifting heavy weights (fig. 1176). For such purposes, and also in war, it has been employed in the East from very remote times. But its nervous temperament and uncertain temper constitute serious drawbacks, especially in the case of the males. Some of the characteristics of this animal are thus described by Sir Samuel Baker (in *Wild Beasts and their Ways*):—"Although I may be an exception in the non-admiration of the elephant's sagacity to the degree in which it is usually accepted, there is no one who more admires or is so foolishly fond of elephants. . . . There is, however, a peculiar contradiction in the character of elephants that tends to increase

the interest in the animal. If they were all the same, there would be a monotony; but this is never the case, either among animals or human beings, although they may belong to one family. The elephant, on the other hand, stands so entirely apart from all other animals, and its performances appear so extraordinary owing to the enormous effect which its great strength produces instantaneously, that its peculiarities interest mankind more than any smaller animal. Yet, when we consider the actual aptitude for learning, or the natural habits of the creature, we are obliged to confess that in proportion to its size the elephant is a mere fool in comparison with the intelligence of many insects. . . . It actually does nothing remarkable, unless specially instructed; but it is this inertia that renders it so valuable to man. If the elephant were to be continually exerting its natural intelligence, and volunteering all manner of gigantic performances in the hope that they would be appreciated by its rider, it would be unbearable; the value of the animal consists in its capacity to learn, and in its passive demeanour until directed by the mahout's commands." The same writer advocates, in the following words, the domestication of the African species:—"It is much to be regretted that no system has been organized in Africa for capturing and training the wild elephants, instead of harrying them to destruction. In a country where beasts of burden are unknown, as in equatorial Africa, it seems incredible that the power and the intelligence of the elephant have been completely ignored. . . . When we consider the peculiar power that an elephant possesses for swimming long distances, and for supporting long marches under an enormous weight, we are tempted to condemn the apathy even of European settlers in Africa, who have hitherto ignored the capabilities of this useful creature. The chief difficulty of African commerce is the lack of transport. The elephant is admirably adapted by his natural habits for travelling through a wild country devoid of roads. He can wade through unbridged streams, or swim the deepest rivers (without a load), and he is equally at home either on land or water. His carrying power for continued service would be from 12 to 14 cwts.; thus a single elephant would convey about 1300 lbs. of ivory in addition to the weight of the pad. The value of one load would be about £500. At the present moment such an amount of ivory would employ twenty-six carriers; but

as these are generally slaves which can be sold at the termination of the journey, they might be more profitable than the legitimate transport by an elephant." Sir Harry Johnston, while in favour of experiments in this matter, thus expresses his forebodings as to the result.—"The question of its domestication and usefulness to man is a very doubtful one. It is relatively easy to obtain young African elephants, and to tame them in a few days or a few weeks. It is also easy to train them to bear burdens on their backs or to perform other simple tasks, but it cannot be

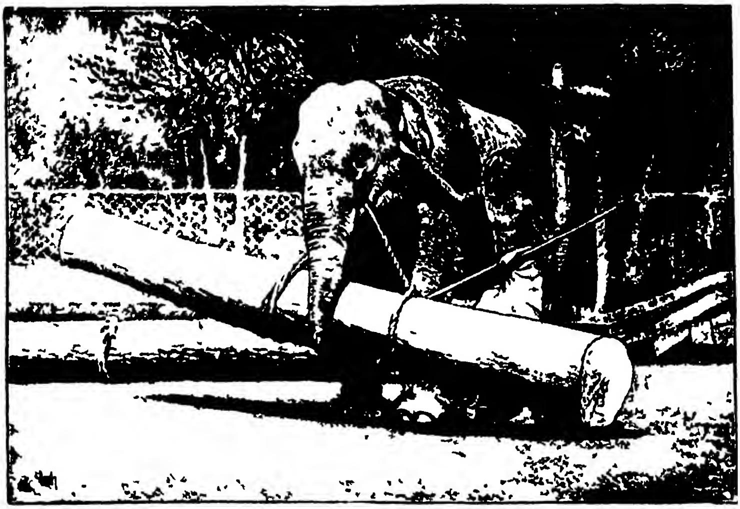


Fig. 1176.—An Indian Elephant (*Elephas Indicus*) lifting Timber

said as they grow up that they evince the same docility that is characteristic of the Indian elephant, while after the males have reached maturity they are positively dangerous. Something might be done with the adult female African elephant." (*Nature*, 1904.)

THE RABBIT (LEPUS CUNICULUS) AND HARE (L. TIMIDUS).—The various breeds of Rabbit which are domesticated in Europe are all descended from the common wild form, which was originally restricted to the countries bordering the Western Mediterranean, and the islands of the same region. Some of the races, especially Chinchillas and Angoras, are valued on account of their fur, the flesh being also utilized (fig. 1177). In this country they are chiefly kept as pets, and for show purposes.

The Rabbit has long played a minor part in the civilization of various peoples, regarding which Darwin gives the following information (in *Animals and Plants under Domestication*):—"The tame rabbit has been domesticated from an ancient period. Confucius ranges rabbits among animals worthy to be sacrificed to the gods, and, as he prescribes their multiplication, they were probably at this early period domesticated in China. They are mentioned by several of the classical writers. In 1631 Gervaise Markham writes: 'You shall not, as in other cattell, looke to their shape, but to their richnesse, onely elect your buckes, the largest and goodliest conies you can get; and for the richnesse of the skin, that is accounted the richest which has the equallest mixture of blacke and white hair together, yet the blacke rather shadowing the white; the furre should be thicke, deepe, smooth, and shining; . . . they are of body much fatter and larger, and, when another skin is worth two or three pence, they are worth two shillings'. From this full description we see that silver-gray rabbits existed in England at this period; and, what is far more important, we see that the breeding or selection of rabbits was then carefully attended to."

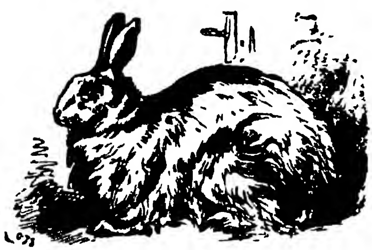


Fig 1177.—Angora Rabbit

Although the Hare cannot now be called a domesticated animal, it was so in ancient Rome, as it happened to be one of the numerous animals relished by the epicure, its shoulder in particular being esteemed a dainty. The animals were kept in a hare-preserve or leporarium, which was a large enclosed park. They were sufficiently tame to come and be fed in winter, a horn being blown as a signal to them. At first, it would seem, intended for hares only, the leporaria were at a later date tenanted by rabbits as well, these having been introduced from Spain.

The Fat Dormouse or Loir (Myoxus glis, fig. 1178).—This was another animal that appealed to the palate of the Roman epicure. Houghton gives the following account of the way in which it was treated (in *Natural History of the Ancients*):—"Dormice (*glires*) were very highly esteemed as food by the old Romans. Small yards were walled around, in which were planted

oak-trees to supply the animals with acorns. These preserves were called *gliraria*; holes were dug in the inside of the yard for the dormice to breed in; a little water was supplied to them, but dry soil was necessary. They were fattened in large jars (*doliis*), and were plentifully supplied with acorns, chestnuts, and walnuts. In these dark places they soon got fat. . . . Dormice

Fig. 1178.—The Fat Dormouse or Loir (*Myoxus glis*)

were considered articles of such luxury that one of the consuls, M. Scaurus, prohibited them by a censor's edict, and, as Pliny says, 'they were banished from our tables'. Notwithstanding this edict, however, a *glirarium* appears to have been an ordinary adjunct of a Roman gentleman's villa. . . . I believe the fat dormouse is still eaten in some parts of Italy, but how far the flavour depended on the inherent good quality of the creature's flesh, or on the mode in which it was cooked, I am unable to say."

BIRD (AVES) AS DOMESTICATED ANIMALS

THE FOWL (GALLUS DOMESTICUS).—The very numerous breeds of domesticated fowls, some of which differ greatly from one another in appearance, are generally held to be all descendants of the Red Jungle Fowl (*Gallus bankiva* or *ferrugineus*), which at the present time ranges from North India through South-east Asia and part of the East Indies to the Philippines. Among the domesticated races Game-Fowls most nearly resemble the original type (fig. 1179).

Fowls are valuable not only because they and their eggs are important articles of diet, but also on account of their feathers, which are put to various uses. Poultry-farming is now rightly regarded as one of those minor agricultural industries upon which the prosperity of the small farmer and the peasant largely depends. A good instance is afforded by the Irish egg-industry. Not many years ago the product was notorious in England on account of the uncertain age of the eggs which were put upon the market; these being only in great demand for election purposes. And the industry, such as it was, benefited the Irish farmer but little, being exploited by persons having no stake in the development of the agriculture of the country. But now, thanks to the co-operative policy of Sir Horace Plunkett, which has been in every way of enormous benefit to Ireland, the Irish eggs, sorted, cleansed, and properly packed, can be sold in the London market within three days after being laid; and the very considerable profits directly benefit the farmers and peasantry. A similar story regarding Irish butter might have been told when the importance of horned stock was emphasized in an earlier paragraph.

Fowls do not appear to have formed part of the live stock of the prehistoric races of Europe, but that they have been tamed for a long period of time will be gathered from the following quotation (Newton—*A Dictionary of Birds*):—"Several circumstances seem to render it likely that Fowls were first domesticated in Burma or the countries adjacent thereto, and it is the tradition of the Chinese that they received their poultry from the West about the year 1400 B.C. By the Institutes of Manu, the date of which is variously assigned from 1200 to 800 B.C., the tame fowl is forbidden, though the wild is allowed

to be eaten—showing that its domestication was accomplished [in India] when they were written. The bird is not mentioned in the Old Testament, nor by Homer, . . . nor is it figured on ancient Egyptian monuments. Pindar mentions it, and Aristophanes calls it the Persian bird, thus indicating it to have been introduced to Greece through Persia, and it is figured on Baby-

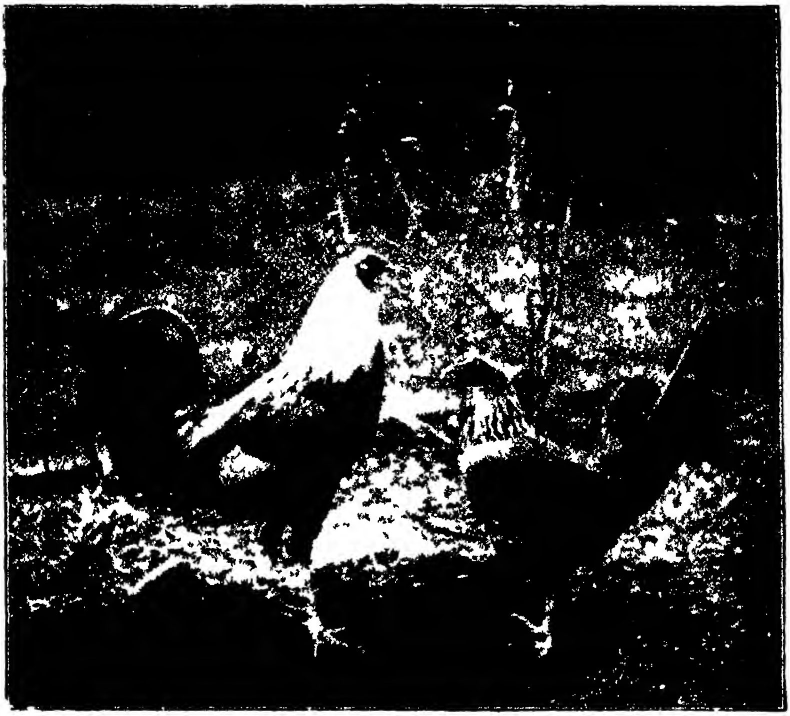


Fig 1179 —Game Fowls

lonian cylinders between the sixth and seventh centuries B.C. It is sculptured on the Lycian marbles in the British Museum (*circa* 600 B.C.), and Blyth remarks (*Ibis*, 1867) that it is there represented with the appearance of a true Jungle Fowl, for none of the wild *galli* have the upright bearing of the tame breeds, but carry their tail in a drooping position."

THE DUCK (ANAS BOSCHAS).—Ducks are of less importance than Fowls, but their uses are much the same. There is little if any doubt that the ordinary breeds of domesticated Duck

are descended from the Mallard or Wild Duck (*Anas boschas*), which has a wide distribution in the Northern Hemisphere. This bird seems to have been tamed at a later date than the Fowl, but it was apparently kept in a state of semi-domestication by the Greeks so long ago as the time of Aristophanes (448(?)-388 B.C.). From them the Romans appear to have learnt its virtues, but we gather from Varro (116-27 B.C.) that in his time the taming process was not complete, for he states that duck-enclosures should be covered with nets, to prevent the escape of their inmates, as well as to exclude predaceous animals.

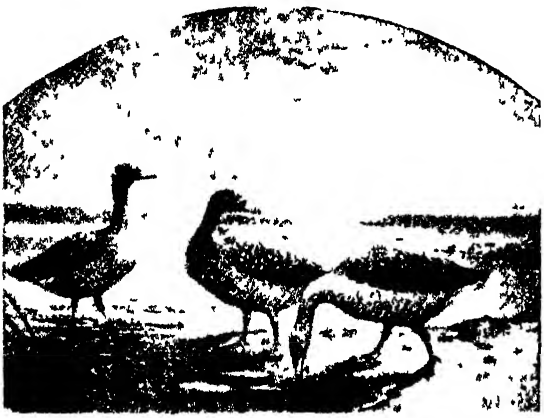


Fig. 1180.—Gray Lag Geese (*Anser cinereus*)

Other species of duck are also domesticated in Europe, especially the Musk or "Muscovy" Duck (*Cairina moschata*) native to South America.

THE GOOSE (ANSER DOMESTICUS).—Geese have been domesticated from very remote times, on which point Darwin remarks (in *Animals and Plants under Domestication*):—"That geese were anciently domesticated we know from certain verses in Homer, and from these birds having been kept (388 B.C.) in the capitol at Rome as sacred to Juno, which sacredness implies great antiquity." It is generally held that the tame European breeds are descended from the Gray Lag Goose (*Anser cinereus*, fig. 1180), native to Britain and most countries of the Continent, and ranging east to China. There are but few domesticated varieties, and these resemble one another and the parent stock more than might be expected, there having been far less variation than, *e.g.* in the case of Fowls. The most obvious difference between a tame and a wild bird consists in the lighter or even perfectly white plumage of the former.

The soft under-feathers of geese are largely used for stuffing pillows and beds, being of greater value in this connection than

those of other domesticated birds. And before steel pens came into general use the large feathers from the wing were in great demand for the making of quill-pens, which even now have many admirers.

THE TURKEY (MELEAGRIS GALLOPAVO).—A native of the southern part of North America, this bird was first described in 1527, and is known to have been domesticated in Europe by 1530, having very likely been introduced early in the century. That it soon found favour in this country is evident from the following facts quoted by Newton (in *A Dictionary of Birds*):—

Fig. 1181.—Guinea Fowls (*Numida meleagris*)

"The earliest documentary evidence of its existence in England is a 'constitution' set forth by Cranmer in 1541. . . . This names 'Turkeycocke' as one of 'the greater fowles' of which an ecclesiastic was to have 'but one in a dishe'. . . . Moreover, the comparatively low price of the two Turkeys and four Turkey-chicks served at a feast of the serjeants-at-law in 1555 (Dugdale, *Origines*) points to their having become by that time abundant, and, indeed, by 1573 Tusser bears witness to the part they had already begun to play in 'Christmas husbandlie fare'"

THE GUINEA-FOWL (NUMIDA MELEAGRIS, fig. 1181).—This form is native to West Africa, and appears to have been domesticated at two different periods, *i.e.* in the times of the ancient Romans, and during the sixteenth century.

Under the term "poultry" may be included fowls, ducks,

geese, turkeys, and guinea-fowl, and the importance of these (especially the first) to agriculture in this country may be seen from the following statistics:—The value of the poultry and eggs consumed in the United Kingdom during 1902 amounted to £16,408,994, including foreign produce worth £7,358,934, Irish produce worth £2,300,000, and produce of Great Britain worth £6,750,000.

THE PIGEON (COLUMBA LIVIA).—The wild Blue Rock-Pigeon (*Columba livia*), the races of which have at the present day a

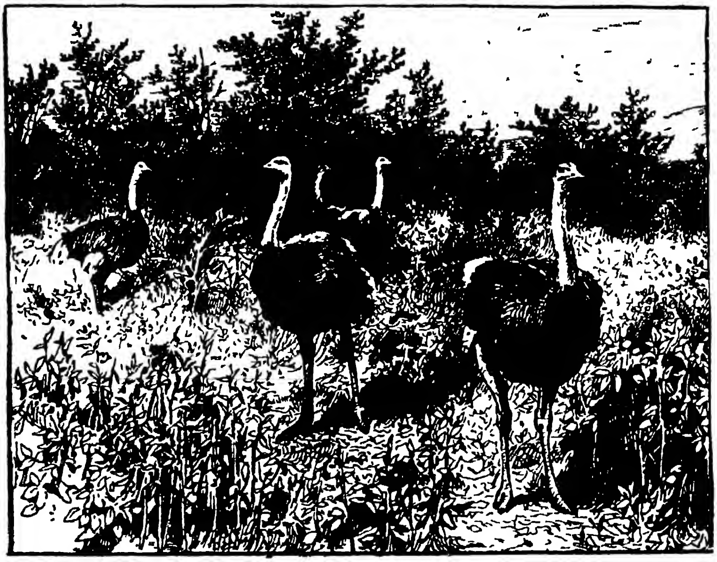


Fig. 118a.—Ostriches (*Struthio camelus*) on a South African Farm

very wide range through Europe, Asia, and North Africa, is believed to be the original stock from which the very numerous domesticated breeds are descended. The ancient Egyptians would seem to have tamed it over 5000 years ago, and it was valued by them not only as a source of food, but also as a means of communication. Its military importance in the latter connections has been abundantly demonstrated in modern times, and it seems destined to play a leading part in the campaigns of the future.

As we shall see in the sequel the theoretical importance of pigeons is very great, for they throw considerable light upon

the question of evolution. The various breeds were studied with the utmost thoroughness by Darwin, and more recent observations show that the subject is by no means exhausted, and that these birds are most desirable subjects for experiment when heredity problems have to be considered.

THE AFRICAN OSTRICH (STRUTHIO CAMELUS).—Although ostriches have been domesticated or semi-domesticated by some of the native tribes of Africa from remote times, the "ostrich farms" of the south are of comparatively recent date (fig. 1182). The inducement to this industry is of course found in the valuable plumage the white wing-feathers being most esteemed, while those of the tail and also some of the back plumes are also marketable. Birds are in their prime when from three to four years old, and the feathers of the males are of better quality than those of the females. They are plucked or cut off about twice in three years, and are subjected to a number of processes before being fit for use. Ostrich-feathers constitute an important export from Cape Colony, yielding not far short of a million pounds sterling annually. The industry has been introduced with more or less success into several other parts of the world, notably Southern California and Australia.

DOMESTICATED INSECTS (INSECTA)

Under this heading may be placed the Honey-Bee (*Apis mellifica*), the Silk-Worm Moth (*Bombyx mori*, &c.), and the Cochineal Insect (*Coccus cacti*). The industries which these insects render possible are all of ancient date, and the two first of very considerable importance.

THE HONEY-BEE (APIS MELLIFICA).—A liking for sweet things is a wide-spread human weakness, and appears to be of very old standing. Wild bees of different kind are native to many parts of the world, and the honey which some of them store in abundance no doubt soon attracted the attention of primitive peoples, whose most important business in life consisted in the discovery of edibles (compare vol. ii, p. 63). Of a small Brazilian species Bates says (in *The Naturalist on the Amazons*):—"A hive of the Melipona fasciculata, which I saw opened, contained about two quarts of pleasantly-tasted honey. The bees . . . have no sting, but they bite furiously when their

colonies are disturbed." Semon complains of the time wasted in the search for honey by the blacks he employed to hunt out the Spiny Ant-Eater (*Echidna*):—"About a dozen black families had gathered in my camp at that period, but only two or three of them performed any work worth mentioning. The control of their day's labour was very difficult, as we were not able to follow them on their rambles, and to make sure of their really pursuing the track of Echidna and not giving themselves up to sweet idleness or to the search of nests of the stingless Australian bee, of the honey of which they are excessively fond. . . . Many an hour destined for labour did they spend in the pursuit of these bees' nests. Still greater was the loss of time when they discovered a nest of our European honey-bee. Mr. Cole, the doctor in Gayndah, was an eager apiarian, and from his hives European bees, which soon became wild, had spread all over the Middle Burnet. . . . Whenever it happened that my blacks discovered a tree which the immigrated bees had chosen as a dwelling, and the hollow of which they had filled with their sweet stores (often to a height of eleven yards or so above the ground), all the mob would at once assemble to fell the mighty tree, often the work of a day." (*In The Australian Bush.*) Readers will doubtless be able to recall appreciative biblical allusions to the desirable properties of honey.

In the case of the Honey-Bee (*Apis mellifica*), with which we are here more especially concerned, the primitive appreciation of sweets led in very early times to the practice of apiculture. As in so many other things the ancient Egyptians would seem to have led the way, their example being zealously followed by both Greeks and Romans. The littoral of the Eastern Mediterranean was possibly the original home of the species, and, if we include varieties, it now has a wide range in the Old World, and has also been introduced into America, the West Indies, Australia, and New Zealand.

As elsewhere sufficiently indicated, the Honey-Bee represents the final term of specialized social life among its kind, though very possibly some features have been brought about by the influence of long-continued domestication. The leading facts about it are so well known that a brief outline may here suffice. A populous hive will contain a queen, several hundred drones or males, and from 30,000 to 50,000 "workers", *i.e.* imperfectly-

developed females, specialized in various ways so as to be able to perform efficiently the varied duties necessary to the maintenance of the community (fig. 1183). The queen is comparatively large, with slender body, short wings, and a curved sting. Maternity is her sole function, and she is fed and tended with the greatest assiduity by the workers. Except for the nuptial flight, and when migrating with a "swarm" to fresh quarters, she does not leave the hive. Only a single queen is tolerated by workers in the same community and if one should happen to emerge from a "royal cell" while the reigning queen is still in the hive a duel to the death ensues. If a queen should intrude from outside the result may be similar, or the workers may mob the interloper, though they will not sting her, and death by starvation or suffocation is commonly her fate. A queen is astonishingly fertile, and under favourable circumstances is capable of laying from two thousand to three thousand eggs in a day. Some of these are unfertilized, and develop into drones, but the majority are fertilized, and are usually destined to produce females, though it is not impossible that some of these also may give rise to drones. The life of a queen extends over four or five years.

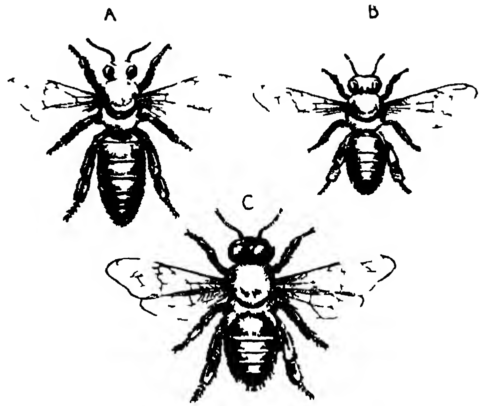


Fig. 1183.—Honey Bee (*Apis mellifica*), enlarged.
A, Queen; B, worker; C, drone.

The stingless drones are smaller and stouter than the queen, and distinguished by the enormous size of their compound eyes. They do absolutely no work, but their presence is patiently submitted to until the end of the summer, because a minute percentage of them are destined to become the fathers of communities. At the approach of autumn, when food is becoming scarce, the drones are mercilessly expelled from the hive, or even, according to some authorities, ruthlessly slaughtered.

The workers are smaller than the drones, and distinguished

by many special characters. One of the most remarkable consists in the possession of a "pollen basket", consisting of a hollow covered by transverse rows of hairs on the inner side of the first joint of the hind-foot (fig. 1184). There are also wax-glands on the under side of the abdomen, by which scales of wax are secreted, this being the chief building material (fig. 1185). The sting is straight, and the mouth-parts better developed than in queen and drones, the proboscis in particular being longer, and well adapted to probe the recesses of flowers in the search for nectar (fig. 1186). These and other specializations are, of course, related to the fact that the workers discharge all the duties of the hive, egg-production alone excepted. A few of them may, however, be fertile under exceptional circumstances, but in that case their eggs invariably hatch out into drones. Workers born late in the season may survive till the following year, but the rest live only for six or eight weeks.

Fig. 1184.—Part of Hind leg of a Worker Bee, greatly enlarged, to show Pollen Basket, above which, on right side, may be seen a pincer-like arrangement used for various purposes

Fig. 1185.—Under Side of a Worker Bee, enlarged, showing plates of wax

The waxen combs made by the workers for storage of food and reception of eggs are suspended vertically, and consist of six-sided cells, of which there is a set on either side of the comb, separated by a thin party-wall (fig. 1187). The long axes of these cells slope slightly outwards and upwards. The smallest of them are for storage and worker-brood, and there is a larger size in which the drones are reared. A comparatively small number of

"royal cells" are constructed at the edges of the combs as circumstances may require. These are somewhat acorn-shaped, with downwardly-directed mouths, and a good deal larger than any of the hexagonal cells. In them the young queens are reared. The workers that produce the wax for comb-construction hang suspended in dense clusters for many hours, until eight little scales of wax have been secreted on the under side of each of them. They then successively visit the highest part of the hive, and

Fig. 1186.—Extended Mouth parts of a Worker Bee, seen from above, with the different regions separated enlarged. The long "tongue" is seen in the centre and the second jaws (1st maxillæ) below.

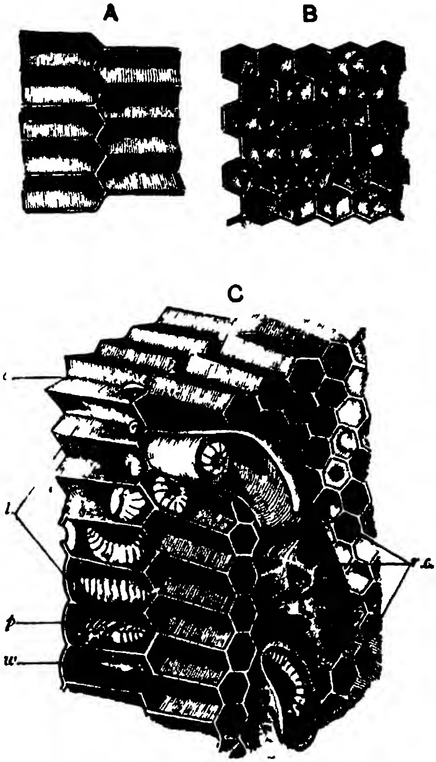


Fig. 1187.—Honey Comb. A, Small cells in section. B, Ditto in surface view. C, Comb with brood: on left development of a worker: egg (e), larvæ (l), pupa (p), imago (w): on right are seen royal cells (r.c.), the middle one unopened.

work the scales into a lenticular mass. The hind-legs are used for detaching the scales, and the jaws for kneading them. Other workers excavate areas corresponding to the cells, building up the walls of these from the wax scooped out, and as the work proceeds the two sides of the comb are simultaneously operated on by two gangs of labourers. At the same time fresh wax is added as required to the edges of the growing comb.

For filling up the crevices of the hive bees employ "propolis", which consists of resin collected from the buds and bark of trees, especially horse-chestnuts and pines. It is carried to the hive in the same way as pollen.

The limbless grubs which hatch out from the eggs in three days' time are fed and tended by the younger workers, and at first receive a soft substance consisting of honey and pollen that have been swallowed and partly digested by their attendants, with which is mixed a fluid secreted by certain glands of the head. This mixture is commonly known as "royal jelly". Larvæ hatched from unfertilized eggs always become drones, but those emerging from fertilized eggs may become either workers or queens, according to the way in which they are fed. A larva which the workers intend shall become a queen is nourished entirely upon royal jelly, possibly differing in composition from that which the others at first receive. It would appear to be of stimulating nature, for queens develop more quickly than members of the other castes, requiring only 15 days (from the laying of the egg) as against 21 for a worker, and 24 for a drone. The larvæ destined to become workers or drones are quickly "weaned", honey, pollen, and water being substituted for jelly. After being fed for 5 days (or 6 in the case of drones) the larvæ attain their full size, when the workers seal the cells with a mixture of pollen and wax, that permits the diffusion of air. Within its cell the larva spins a silken cocoon, imperfect at the hinder-end in the case of queens, and passes into the motionless pupa stage, from which, later on, the perfect insect emerges, to bite its way out into the hive.

When a hive becomes overcrowded the surplus population, accompanied by the reigning queen, "swarms" out of the hive to seek fresh quarters. This never takes place unless one or more royal cells with inmates are present in the deserted home. When the first young queen emerges from these, her first act is to tear open the remaining royal cells and sting the inmates to death, an operation which is rendered possible by the imperfect nature of the cocoons in which these are enclosed. After a nuptial flight the young queen settles down as the new mother of the community. Sometimes the workers will prevent the first emerged young queen from destroying her sisters, and in that case there is a possibility of the first migration being succeeded by after-

swarms or "casts". Domesticated bees are more given to swarming than wild ones.

Bee-Keeping or Apiculture.—The remarks already made about the importance of poultry-keeping (p. 246), as an adjunct to agriculture, apply here also, though to a less extent. To give a long account of the industry is unnecessary, and readers requiring details will do well to consult Cowan's *British Bee-Keeper's Guide Book*. This writer thus speaks of the paying nature of the industry, and the essentials to success:—"The culture of the honey-bee is now universally admitted to be one of the most profitable of rural pursuits. It has engaged the attention of intelligent persons of all ages; yet it is only comparatively recently—by the introduction of improved movable-comb hives, the honey-extractor, and comb-foundation—that this pursuit has been rendered no longer a matter of chance, but as certain and more remunerative with small outlay than any other rural occupation. Much has been written about the enormous profits to be derived from bee-keeping; and, stimulated by what they have read, persons have purchased a few stocks, and, after keeping them without any attention for some years, have given them up, having failed for want of a knowledge of the first principles of bee-culture. Although anyone may keep bees, it is not everyone who can become a proficient bee-master. Energy and perseverance, together with aptness for investigation, can only ensure real success. While some degree of talent is essential, in this as in every other pursuit, ordinary ability directed to the attainment of a specific end will be more likely to be rewarded by success, than the most extraordinary talent divided among half a dozen different pursuits. The man who is thoroughly conversant with his business, is familiar with its requirements, has mastered its every detail, and who is industrious and energetic, will be likely to succeed; and if, in addition to this, he possesses good executive abilities, his success will be very apt to be above the average."

A few words may be of interest on the three requisites to enlightened apiculture mentioned in the above extract, *i.e.* movable-comb hives, honey-extractors, and comb-foundation. The familiar bell-shaped straw hive or "skep" may be picturesque, but is eminently undesirable. It renders regulation of the bees' labours impossible, necessitates destruction of the combs, and too often means that the industrious insects are choked by the fumes

of burning sulphur as a preliminary to taking their honey. All this is altered in the movable-comb or "frame" hives (fig. 1188). These are square wooden boxes, which open at the top, and contain a number of wooden frames for holding the combs, and easily taken out at pleasure for the purposes of the bee-keeper. They render it easy to regulate the bees, including the swarming, in almost any required way. The reigning queen, for example, can be deposed, and replaced by a more fertile successor, or one of more desirable race.

The honey-extractor is a simple device for rapidly rotating combs so that the honey flies out by centrifugal force, and this is a vast improvement on the old method of crushing and straining. As Cowan very justly remarks:—"When we bear in mind that bees consume about 20 pounds of honey in order to produce one pound of wax, we can realize the advantages of a machine which enables us to give them empty comb, and thus save them the labour of comb-building".

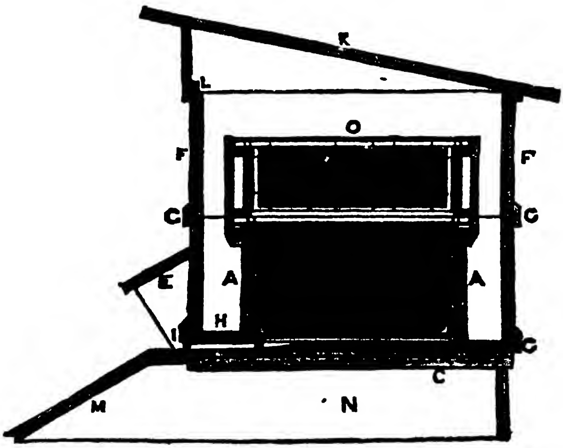


Fig 1188.—Cowan Hive in Longitudinal Section A Body box B, floor board, C, strengthening piece D, entrance gallery E, entrance porch F, outer case, G, protective plinths H, roof of entrance gallery I, sliding door at entrance, K, roof, L, roof catch M, alighting board N, stand, O, rack with three sections, below which is seen a frame of comb.

To supply comb-foundation is the next best thing to giving empty combs. This consists of thin plates of wax, which have been passed between suitably-embossed rollers, so that the "foundations" of the cells are laid, and there are also projecting ridges of wax, furnishing enough material for the completion of the cells, save that required to cover them. Foundation is made with either small cells suitable for worker-brood (or storage), or with larger cells adapted for drone-brood. It is possible, by supplying one or other kind as desired, to regulate within certain limits the number of workers and drones produced in the hive.

There unfortunately appear to be no means of ascertaining how far British apiculture is profitable. Honey to the value of £30,349 was imported into this country in 1903.

THE SILK-WORM MOTH (BOMBYX MORI, &c., fig. 1189).—The most important and best-known kind of Silk-Worm Moth is the one (*Bombyx mori*) of which the caterpillar or "silk-worm" feeds upon the leaves of the mulberry-tree. The life-history is sufficiently familiar. From the egg a minute larva hatches out which is full grown in about five weeks, during which time it casts its skin several times. At the end of this period the silk-worm spins a cocoon, which consists of two long threads, the hardened secretion of two large glands that open on the under-lip.

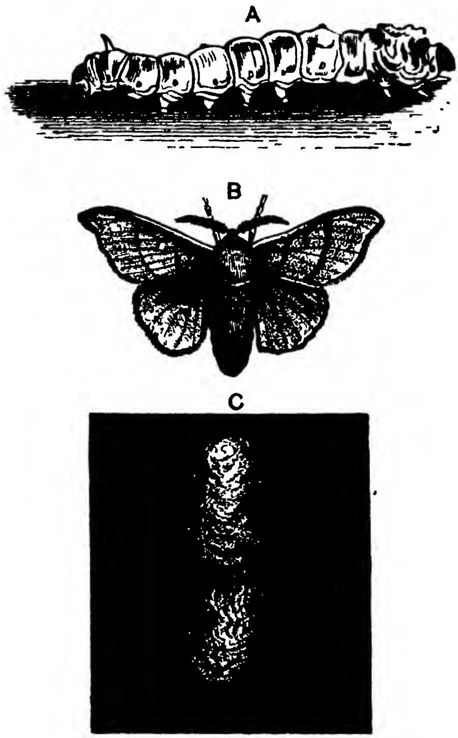


Fig 1189.—Silk Worm Moth (*Bombyx mori*). A, Caterpillar (silk-"worm"). B, female moth. C, cocoon

The material known as "cat-gut" is made from the secretion of the silk-glands, which are removed from the caterpillar and subjected to suitable treatment.

The culture of silk-worms is generally supposed to have been first practised in China, the first allusion to it dating back to 2640 B.C., according to Chinese records. Thence the industry spread through Korea into Japan, and also into India, Persia, and Central Asia. Its introduction into Europe is ascribed to the Emperor Justinian, who is said to have induced a couple of Persian monks to undertake a journey to China with the view of surreptitiously obtaining eggs. These worthies are stated to have been successful in their mission, reaching Constantinople with a supply of eggs (concealed in bamboos) in the year 550 A.D. To this source the silk-industry of Southern Europe

may be traced, and to France and Italy, in particular, it is now of great importance. In the former country about 137,500 cwts. of raw silk (worth £1,080,000) is produced annually, while the Italian yield in 1902 was 823,718 cwts. (worth £12,355,057).

Of late years the Chinese have engaged in the culture of the Oak Silk-Moth (*Saturnia Pernyi*), of which the larvæ feed on oak-leaves. The silk is coarser and less valuable than the ordinary kind, but possesses the merit of greater strength. An allied species (*S. yama-mai*) is cultivated in Japan.

How far silk is important to Britain may be gathered from the fact that in 1902 we imported 1,252,848 lbs. of raw silk worth £728,020, and silk goods to the value of £14,321,541.

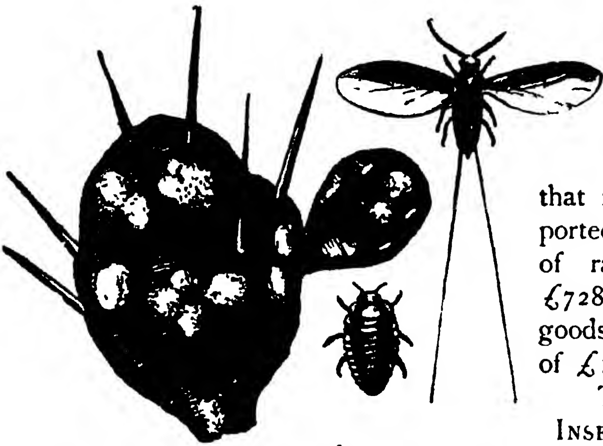


Fig. 1190.—Nopal (*Opuntia coccinellifera*) and Cochineal Insects (*Coccus cacti*), enlarged, female to left, male to right

THE COCHINEAL INSECT (COCCUS CACTI, fig. 1190).—The colouring-matter known as cochineal, as also (to some extent) the pigments known as carmine and lake, are derived from a species of bug native to Mexico, which feeds upon the Nopal (*Opuntia coccinellifera*), a plant of the cactus sort. The culture of this insect dates back to the times of the ancient Mexicans, and is now of some importance in Central America. The insect and its food-plant have also been successfully introduced into the Canary Islands, Algeria, Java, and Australia. The colouring-matter is obtained from the dried bodies of the female insects, which are ground and extracted. It requires about 70,000 of them to produce a pound of cochineal. The introduction of cheap aniline dyes has caused this industry to decline, while carmine and lake can now be manufactured chemically.

HUMMING-BIRDS (*Trochilidæ*)

These brilliantly-coloured little forms, of which between 400 and 500 species have been described, are perhaps the most attractive members of their class, and some of them are the smallest known birds. Excluding the tail, which is often long out of all proportion, they vary in length from 8½ to rather less than 2½ inches. They are wholly American (and West Indian), ranging from Tierra del Fuego to Canada, and from sea level to a vertical height of 16,000 feet. The mountains and hills of the northern parts of South America are inhabited by the largest number of beautiful species. Unfortunately, like many other birds of attractive plumage, they are ruthlessly hunted down to minister to the vanity of womankind.

The species represented in the plate are 1. *Lamprolæma rhami*, 2 *Thalurania furcata*, 3. *Lesbia sparganura*, 4 *Calypte Helenæ*, 5. *Diphlogæna hesperus*.

HUMMING-BIRDS (TROCHILIDAE) OF AMERICA

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CHAPTER LXVIII

ANIMAL FRIENDS—FISHES, MOLLUSCS, AND CRUSTACEANS AS FOOD—FISHERIES

To do anything like justice to the "harvest of the sea", not to mention the "freshwater harvest", would require a very considerable space, but the importance of the subject may be sufficiently illustrated for the purposes of this book by a few salient facts and figures. It will be convenient to successively consider Fishes, Molluscs, and Crustaceans, beginning in each case with a brief account of the more valuable species, and adding a few remarks on fisheries, culture-methods, &c. In the preparation of this chapter the writer has been greatly helped by Mr. J. T. Cunningham's *Marketable Marine Fishes*, as well as by papers and MS. notes by Professor J. Travis Jenkins.

Much kind assistance has also been given by the Secretaries to the French, German, Italian, Russian, and U.S. Embassies, the Legations of Holland and Scandinavia, the Italian Chamber of Commerce, the Imperial Russian Financial Agency, our own Department for Agriculture and Fisheries, and the Whitstable Oyster Fishery Company; also by the U.S.A. and Newfoundland Fisheries Departments, the High Commissioner for Canada, and the British Consuls-General in Christiania, Paris, and St. Petersburg.

FISHES (PISCES) AS FOOD

Without entering into minute technical details, it will be desirable in the first place to say a little about the three chief methods by which fishes are captured on a commercial scale, *i.e.* line-fishing, net-fishing, and trawling.

Line-Fishing. — Before the prehistoric races of Western Europe had learnt the use of metals there is evidence to show that large fishes, such as salmon, were secured by means of

bone harpoons, and the earliest fish-hooks were made of bone or shell. The remains from the Age of Bronze include a number of fish-hooks of that metal, and of these our modern devices of the same nature are doubtless lineal descendants. The most extensive development of line-fishing in this country is exemplified on the Scottish coasts, where such fishes as cod, haddock, and ling are thus caught. A series of cod-lines may reach the great length of eight miles, and carry 4680 hooks on attached "snoods", the favourite bait being whelks. The somewhat shorter haddock-lines are mostly baited with mussels or lug-worms.

Net-Fishing.—This more wholesale method of capture has the advantage of obviating the trouble and expense of bait. *Drift-nets* afford the chief means of catching fishes which, like herrings, pilchards, and mackerel, swim in large shoals at or near the surface, and they are nearly always worked at night. Such a net is practically a curtain, of which the upper edge is floated by corks, while the lower edge is sunk by weights. If by skilful manœuvring a shoal can be induced to dash against the meshwork, their heads easily pass through (the size of mesh being adapted to the particular species), and the projecting gill-covers prevent withdrawal. For herrings a series or "train" of drift-nets may extend a distance of 1¼ mile, while for mackerel the length may be twice as great. *Seines,* which may be as much as 1200 feet in length, are hanging nets which are drawn round shoals of fishes so as to enclose and secure them as in a bag. After the catch is made it may be hauled on to fishing-boats or drawn to shore according to circumstances. Certain other smaller nets will be mentioned as occasion arises.

Trawling.—This is, of course, a variety of net-fishing, and specially adapted for the wholesale capture of fishes that live on or near the bottom. The "trawl" or "beam-trawl" (fig. 1191) is essentially a large, flat, tapering net, which is dragged over the sea-floor, and may be as much as 100 feet long, with a mouth 50 feet wide. The "beam" is a horizontal spar by which the mouth is kept open, and which does not scrape along the bottom as sometimes supposed. It would be out of place here to describe all the elaborate details of construction. For most purposes trawling, especially as practised by steam-vessels, is rapidly superseding some of the older methods of fishing. And as it not only means the capture of vast quantities of

adult fishes, but also destruction of great numbers of immature individuals, trawling cannot but tend to deplete the natural supply. It is to be hoped that our knowledge will ultimately be sufficiently extensive and accurate to grapple with the question as to how best to regulate this kind of fishing, with a view to maintaining the more important species in sufficient numbers. At present our ignorance on many points is considerable, not to say profound, and there is no lack of exaggeration on a slender basis of fact.

THE HERRING FAMILY (CLUPEIDÆ).—The members of this family are widely distributed in the coastal waters of both tropical and temperate seas, but are not found in the deeper parts of the ocean. From the economic standpoint they are the most valuable of all food-fishes, which is partly due to the fact that they live in large surface-feeding shoals. The chief method of capture is by means of "drift-nets". The most important British fishes belonging to the family are Herring, Sprat, Pilchard, and Anchovy.

Fig 1191 —Trawl Net attached to Fishing Boat

The Herring (*Clupea harengus*, fig. 1192).—Of all European marine fishes this contributes most largely to the human food-supply, especially when converted by curing methods into the familiar "red herring", "kipper", and "bloater". It was long supposed that herrings migrated periodically from northern waters to the south, on both sides of the North Atlantic, but their movements are now believed to be of much more local character. It may, in fact, be stated that the direction of these movements is alternately towards and from the land, the former being undertaken for the purpose of spawning in shallow water, where the heavy, sticky eggs sink to the bottom and adhere to various

objects. In British seas a distinction may, somewhat doubtfully, be drawn between "summer" and "winter" herrings, which appear to be two distinct varieties or races that spawn respectively at the seasons indicated. Winter herrings favour estuaries, and it is they which are fished, for example, in the Firth of Forth, Firth of Clyde, and Plymouth Sound. Summer herrings, on the other hand, avoid estuaries, and their spawning-grounds may be at some distance from the coast. They are the

Fig. 119a.—Part of a Shoal of Herrings (*Clupea harengus*)

more important race, and are caught in vast numbers on the north-east coasts of Scotland and the east coast of England.

The Sprat, Pilchard, and Anchovy, which next fall to be considered, lay floating eggs, like the large majority of marine fishes.

The Sprat (*C. sprattus*).—This small species ranges from the north of Europe to the Mediterranean, and is largely fished from the coast of Kent round our south-east and south shores to Devonshire.

It appears that what is popularly known as "whitebait" is not a distinct kind of fish, but is chiefly made up of very young herrings and sprats, both of which are fond of making their way into sheltered estuaries.

The Pilchard (*C. pilchardus*).—This fish is pretty much like a herring in appearance, but its body is of rounder shape, the scales are very large, and there are several other points of difference. It ranges from the south of Ireland and England to Madeira, and into the Mediterranean. As is well known, the pilchard fishery of Cornwall is one of the most important industries of that county.

Sardines are simply young pilchards, and not a distinct species as sometimes supposed. They are fished on a large scale on the west of France, and also off the coast of North-west Spain (Galicia). Sardines are caught by the French to the value of some £400,000 per annum. Our own import of preserved fish (largely sardines) from France in 1902 was worth £373,960.

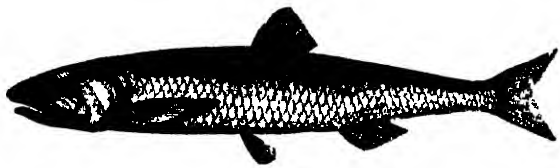


Fig. 1193.—Anchovy (*Engraulis encrasicholus*)

The Anchovy (*Engraulis encrasicholus*, fig. 1193).—This slender little fish, which is best known to us as the source of various flavourings, is easily distinguished from its congeners by the way in which its snout projects in front of the mouth, so that this opens on the under side of the head, much as in a shark. The anchovy ranges from the coast of Norway down the sea-board of Western Europe, and through the Mediterranean. Although native to our seas it is not the object of a British fishery, but the Dutch capture it in large numbers, in the Zuyder Zee and the estuary of the Scheldt, by means of small drift-nets fixed at either end, netted gaps between willow- and poplar-fences (near Bergen-op-Zoom), and by large sweep-nets. The importance of the anchovy-fishery to Holland will be realized from the fact that in 1902 the catch amounted to 100,000 ankers (an anker = about 88 lbs.). At Bergen-op-Zoom in that year 127 cwts. of these fishes were cured, over 77 cwts. of salt being used in the process. In the anchovy-fisheries along the Mediterranean littoral of Spain, France, and Italy drift-nets and seines are employed.

THE COD FAMILY (GADIDÆ).—From the economic stand-point

this family ranks second only to the one just considered. The fishes it includes are voracious ground-feeders characteristic of polar and temperate regions. With few exceptions they are marine, and their favourite habitat is in water under 200 fathoms in depth. Trawling and line-fishing are the chief methods by which they are captured. The most notable British species are Cod, Coal-Fish, Haddock, Whiting, Ling, and Hake. All of these lay floating eggs.

The Cod (*Gadus morrhua*, fig. 1194).—This large and important fish is the most valuable member of its family so far as its range extends, *i.e.* from Arctic seas to the Bay of Biscay on one side of the North Atlantic, and as far as

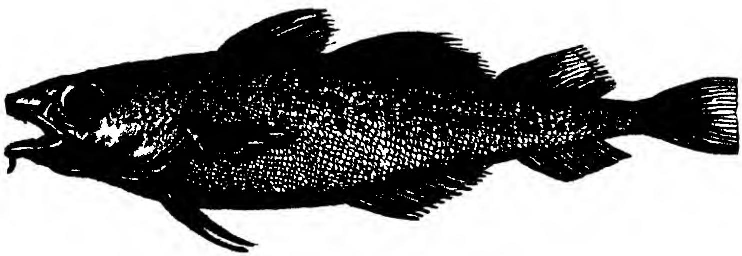


Fig. 1194.—Cod-Fish (*Gadus morrhua*)

New York on the other side. Günther thus summarizes some of the chief points regarding it (in *The Study of Fishes*):—"The Cod-Fish occurs between 50° and 75° lat. N. in great profusion, but is not found nearer the equator than 40° lat. Close to the coast it is met with singly all the year round, but towards the spawning-time it approaches the shore in numbers, which happens in January in England and not before May on the American coasts. The English resorted to the cod-fisheries of Iceland before the year 1415, but since the sixteenth century most vessels go to the banks of Newfoundland, and almost all the preserved cod consumed during Lent in the various Continental countries is imported from across the Atlantic. At one time the Newfoundland cod-fishery rivalled in importance the whale-fishery and the fur trade of North America." The Newfoundland catch for 1902 weighed about 140,000 tons.

The Coal-Fish (*Gadus virens*).—This fish, locally known as "green cod" and "saith", is somewhat smaller than the ordinary

cod, and ranges from the Arctic Ocean into the Mediterranean. It is largely fished in northern British waters, and is cured to a considerable extent.

The Haddock (*Gadus æglefinus*, fig. 1195).—Though of superior quality in the fresh condition, this fish is perhaps more familiar in the cured state, under the names of "yellow fish", "Finnan haddie", and so forth. In British seas average specimens are decidedly smaller than cod, and are easily recognizable by the blackness of the lateral line, and by the presence of a black blotch above the pectoral fin, attributed by tradition to

Fig. 1195.—Haddock (*Gadus æglefinus*)

the finger and thumb of the apostle Peter, though the John Dory is another candidate for the honour of the association. The range of the haddock is much the same as that of the cod, but it is only of marked importance in regard to the northern half of the British fishery area.

The Whiting (*G. merlangus*).—This comparatively small species is noted for delicacy of flavour, but to fully appreciate this it must be eaten immediately after capture, for it rapidly deteriorates, and stands carriage badly. Though ranging from Norway to the Mediterranean, and found all round our coasts, it is of more importance to the fisheries of the English Channel than to those farther north.

The Ling (*Molva vulgaris*).—This is a large and rapacious fish, which is largely cured, but is decidedly inferior to the

haddock. It ranges from the Arctic Ocean as far as Gibraltar on the east of the North Atlantic, but only to Newfoundland on the west. It is mostly fished in the northern parts of the North Sea, and around the shores of the Orkneys, Shetlands, and Faroe Islands.

The Hake (*Merluccius vulgaris*).—Like the last-named species this is a rapacious fish of large size. Its range is similar to that of the cod, except that it is found throughout the Mediterranean, and is most abundant on the southern shores of Britain. Like most large forms it is somewhat coarse and not greatly esteemed as food, though hake steaks are not to be despised.

THE FLAT-FISH FAMILY (PLEURONECTIDÆ).—These are carnivorous ground-fishes of great economic importance, especially in the north temperate region, and for delicacy of flavour some of the species are unrivalled. The valuable British forms which deserve notice are Turbot and Brill, with eyes on the left side; and Sole, Plaice, Flounder, Dab, and Lemon Dab, in which the eyes are on the right side. All these species lay buoyant eggs. Trawling is by far the most important method of capture, after which comes line-fishing.

The Turbot (*Rhombus maximus*).—This is the most esteemed of the larger flat-fishes, and may attain a weight of over 20 lbs. It is a shallow-water form, and ranges from the Black Sea, through the Mediterranean, up the eastern coast of the North Atlantic as far as Denmark and South Scotland. Bony tubercles are imbedded in the skin of the left side. In accordance with the fact that the turbot is highly predaceous, feeding upon other fishes, its mouth is larger than in most members of the family.

The Brill (*R. lævis*).—Except in its smaller size, and the absence of tubercles on the skin, this species resembles the turbot in appearance, mode of feeding, and distribution.

The other flat-fishes to be noticed here all have the eyes on the right side of the body and (except the Halibut) have small mouths, adapted to feeding on worms and other small creatures.

The Halibut (*Hippoglossus vulgaris*).—This is the largest of all flat-fishes, and is said to sometimes reach the length of 20 feet, while individuals of 6 or 7 feet long are often caught in British seas. A 7-foot halibut weighs somewhere about 300 pounds or rather more. It is a decidedly northern species, and appears to range right round the southern shores of the Arctic

Ocean. In the Atlantic its area of distribution extends as far south as the English Channel. The halibut feeds on fishes and crustaceans.

The Sole (*Solea vulgaris*, fig. 1196).—This valuable and delicately-flavoured food-fish, adult specimens of which average from 12 to 18 inches in length, is distinguished from many other forms by its shape, which is a narrow oval with continuous outline, free from sharp curves or projections. It ranges from the Mediterranean to the south of Scotland, and is captured for the most part in water under 30 fathoms deep.

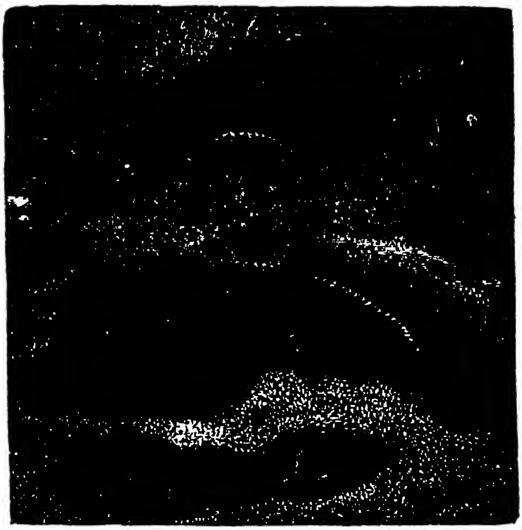


Fig 1196 —Soles (*Solea vulgaris*

The Plaice (*Pleuronectes platessa*).—This common British species is of considerable economic importance, though its flesh is rather flavourless. Average specimens vary from 15 to 18 inches in length, but a larger size is often reached, especially in northern waters. The plaice may easily be recognized by the large orange-coloured or rust-red blotches on the dark side of the body. It ranges from the north coast of Europe as far south as the Bay of Biscay.

The Flounder (*P. flesus*).—This is a rather small species, the pigmented side of which is dark-brown or black. It ranges along the entire west coast of Europe, and is also found in the Baltic and Mediterranean. Flounders are estuarine fishes, and are able to live in fresh water.

The Dab (*P. limanda*).—This is about the same size as the flounder, but its pigmented side is of light-brown colour, with darker spots, and the skin is rough. It ranges from the north of Europe to the Bay of Biscay, and is found both in estuaries and the open sea.

The Lemon Dab (*P. microcephalus*).—This is often sold under the name of Lemon "Sole", but it is a poor substitute for the true Sole, which it resembles in shape though not in colour. The dark side of the body is of a yellowish-brown, marked with numerous spots The range is practically the same as that of the Dab, but it is most abundant in fairly deep water.

THE MACKEREL FAMILY (SCOMBERIDÆ).—The members of this family are highly predaceous tropical and temperate fishes which swim in shoals in the open sea, but approach the land in pursuit of prey. Their form admirably adapts them to swift progression (see vol. iii, p. 41). It will be necessary here to consider two

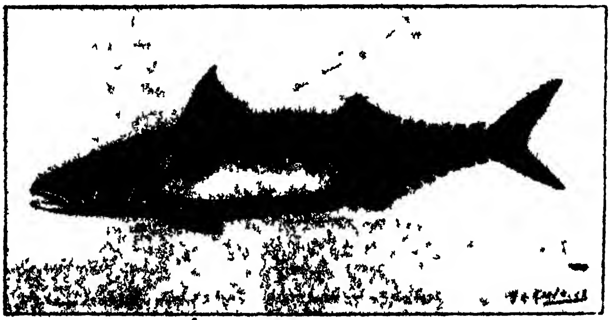


Fig 1197.—Mackerel (*Scomber vernalis*)

species, the Mackerel and Common Tunny, both of which lay floating eggs.

The Mackerel (*Scomber vernalis*, fig. 1197).—This is one of the most beautiful of our native marine fishes, and adults vary in length from about 1 foot to 17 inches. The range is from the Mediterranean to the Canaries, and north along the shores of Europe to the south of Norway. So far as British fisheries are concerned mackerel are of importance from the coast of Norfolk round the Straits of Dover to Devon and Cornwall. Drift-nets and seines are the chief means of capture, but lines are also employed, especially in the south-west of England.

The Common Tunny (*Orcynus thynnus*).—This can be described as a gigantic mackerel, which may reach a length of 10 feet, and a weight of about half a ton. Although sometimes taken in the North Sea and Baltic it is essentially a native of the Mediterranean, where it has been the object of an important

fishery from very early times. Its flesh is eaten both when fresh and in the preserved condition. Pickled Tunny (*Saltamentum Sardicum*) was considered a delicacy by the ancient Romans. The Italian tunny-fishery, of which Sardinia and Sicily are the chief centres, is a considerable industry, which yielded over £111,000 in 1902. It commences in spring, when the fish approach the shore to spawn, and the shoals are either driven into shallow water and surrounded by a series of strong nets, or else chased into a sort of net-labyrinth, in the innermost compartment of which they are slaughtered with clubs, boat-hooks, and the like.

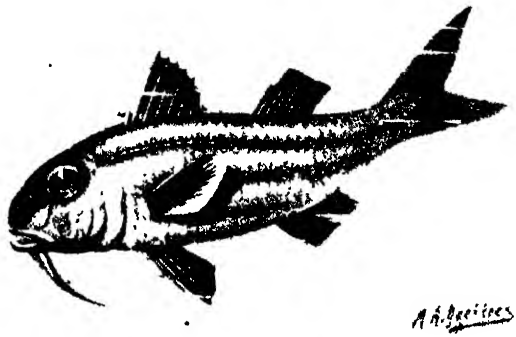


Fig. 1198.—Striped Red Mullet (*Mullus surmulletus*)

The Red Mullet Family (Mullidæ).—The members of this family are mostly tropical fishes, but one species, the Striped Red Mullet (*Mullus surmulletus*, fig. 1198), is common in the Mediterranean, from which it ranges to the Canaries and Norway. It is taken in some numbers off the south and south-west shores of England by means of small drift-nets known as trammels. Average specimens weigh about half a pound. It is a particularly handsome fish, of bright-red colour (except below), with several narrow yellow bands along its sides. There is also a Plain Red Mullet (*M. barbatus*), without the stripes, which is common in the Mediterranean, and is occasionally taken in British waters. Most probably it is a distinct species.

The Red Mullet is universally regarded as a delicacy, and its flavour has suggested the popular name of "sea woodcock". The epicures of ancient Rome were extravagantly fond of it. On this

point Günther remarks (in *The Study of Fishes*): "The Romans prized it above any other fish; they sought for large specimens far and wide, and paid ruinous prices for them. . . . Then, as nowadays, it was considered essential for the enjoyment of this delicacy that the fish should exhibit the red colour of its integuments. The Romans brought it, for that purpose, living into the banqueting-room, and allowed it to die in the hands of the guests, the red colour appearing in all its brilliancy during the death struggle of the fish. The fishermen of our times attain the same object by scaling the fish immediately after its capture, thus causing a permanent contraction of the chromatophores containing the red pigment."

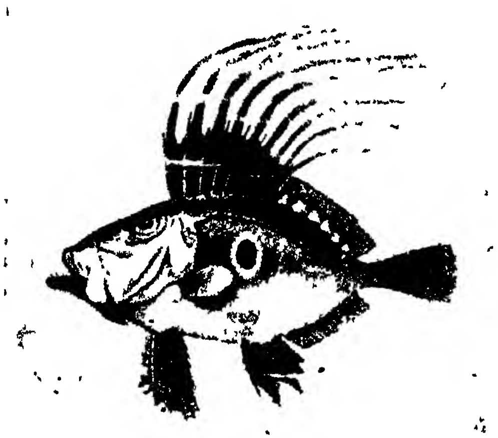


Fig. 1199.—John Dory (*Zeus faber*)

THE JOHN DORY FAMILY (CYTTIDÆ).—The members of this family inhabit temperate seas, and, so far as known, lay floating eggs. The body is greatly flattened from side to side. Other fishes constitute the food. Only one species requires notice, *i.e.* the *John Dory* (*Zeus faber*, fig. 1199), which may be of considerable size (up to 18 lbs in weight). Its narrow body is very deep, while the elongated first dorsal fin and large staring eye give it an extraordinary appearance. The colour is greenish-brown, banded with yellow, and on either side of the body there is a large round black patch with a yellow border. Gunther says (in *The Study of Fishes*):—"The fishermen of Roman Catholic countries hold this fish in special respect, as they recognize in a black round spot on its side the mark left by the thumb of St. Peter when he took the piece of money from its mouth". (See also p. 267.) The John Dory ranges from the Mediterranean to Madeira and Norway. It is trawled in considerable numbers in the English and Bristol Channels.

THE GURNARD FAMILY (COTTIDÆ).—Here are included widely

distributed ground-fishes, living in shallow water. Among them are the little *Bull-Heads* (*Cottus*), some of which are common on our coasts, while one, the Miller's Thumb, is a familiar inhabitant of our brooks. They are of no economic importance, though the Germans make soup of the last-named form. The larger Gurnards, however, are valuable food-fishes, of which several are British. They lay floating eggs. The head is large and covered with strong plates, while some of the rays of the pectoral fins are free and serve as feelers. The commonest native species are the *Grey Gurnard* (*Trigla gurnardus*) and the *Red Gurnard*

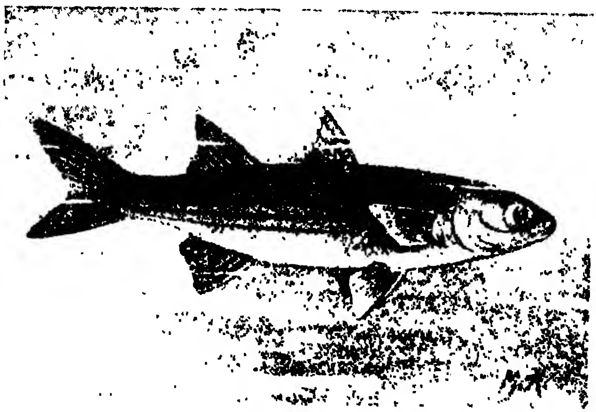


Fig. 1200.—Thin-lipped Grey Mullet (*Mugil capito*)

(*T. cuculus*), both of which range from the Mediterranean to Norway. The latter is most abundant in the English Channel, and the former in the North Sea.

The Grey Mullet Family (Mugilidæ).—Grey Mullets are handsome forms common on temperate and tropical coasts. They frequent inlets and estuaries, where they feed on vegetable food. There appear to be two species, the *Thin-lipped* and *Thick-lipped Grey Mullets* (*Mugil capito*, fig. 1200, and *M. chelo*), which range from the Mediterranean into British seas. Both are silver-grey in colour with longitudinal black streaks, and distinguishable from each other by the nature of the lips as indicated in their names. They are taken in large numbers by seines and other nets on the south coast of England, but the thick-lipped species seems to be more common off the western part of this area.

So far we have considered marine food-fishes, and it will be

now appropriate to make some reference to the members of the Eel and Salmon families, which, in a sense, link together the forms of sea and fresh water.

THE EEL FAMILY (MURÆNIDÆ).—Eels are more or less cylindrical fishes, which may either be scaleless or possess minute scales sunk in the skin. They are widely distributed through the fresh waters and seas of the tropical and temperate regions, some of the most specialized kinds inhabiting the abysmal parts of the ocean. They are captured either by hook and line or by means of wicker-work (or metal) traps, provided with funnel-shaped openings. Trident-shaped eel-spears, with numerous tines, are also used in some localities. Creatures of the kind have been esteemed as a savoury food from very remote times, the ancient Greeks and Romans, for example, being extremely partial to them. There are two British species, the Conger and the Common Eel.

Fig. 1201.—Conger Eels (*Conger vulgaris*)

The Conger (*Conger vulgaris*, fig. 1201).—This is a large, scaleless marine eel, which not uncommonly attains the length of 6 or 7 feet and a weight of 60 lbs. It is a shallow-water form, and has a very wide distribution, occurring all round the shores of Europe, and also inhabiting the coastal waters of St. Helena, Japan, and Tasmania.

The Common Eel (*Anguilla vulgaris*).—This is a good deal smaller than the Conger, but full-grown specimens attain a length of 3 feet. When adult it inhabits fresh water, but repairs to the deep sea to spawn, the young eels or elvers making their way up rivers after undergoing a rather startling kind of transformation (see vol. iii, p. 433). This species has a wide distribution in the river-systems that discharge their waters into the North Atlantic (west as well as east coast) and Mediterranean.

THE SALMON FAMILY (SALMONIDÆ).—Salmonoid fishes are both commercially important and also of interest from the sporting point of view. About the middle of the back there is a dorsal fin of the usual character, and some distance behind this a small fatty or adipose second dorsal, unsupported by fin-rays. The nature of this second fin is a distinctive character. The family includes various species of Salmon, Trout, Charr, Grayling, and Smelt. All are natives to the non-tropical parts of the Northern Hemisphere, with the exception of a kind of Smelt (*Retropinna Richardsoni*) found in New Zealand and the Chatham Islands.

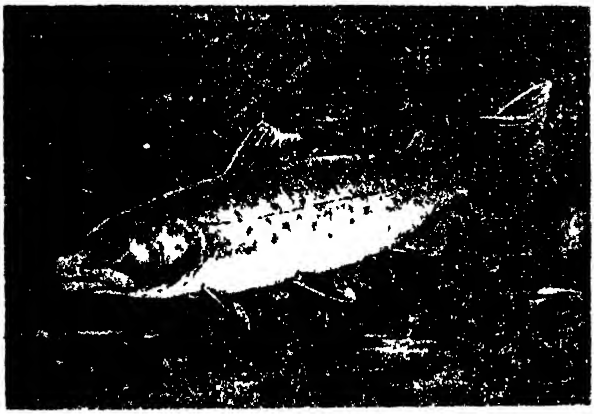


Fig. 1202.—River Trout (*Salmo fario*)

Some of the salmonoids are purely marine, others never leave fresh water, and others again may be described as marine forms which ascend rivers to spawn. The eggs are heavy and adhesive. Only a few important species require mention here.

The Salmon (*Salmo salar*).—This universally esteemed fish spawns in the rivers of temperate Europe as far south as 43° N. lat., and those of temperate North America down to 41° N. lat. In Britain it reaches commonly a weight of 20 to 40 lbs., and much larger specimens have been recorded. Salmon are eaten not only when fresh, but also, especially in North Europe, in the smoked condition. The chief method of capture is by netting at the time when the fish are ascending rivers, but large numbers are also taken with the rod.

The River Trout (*Salmo fario*, fig. 1202).—Average adult specimens of this well-known angler's fish attain the weight of

about 1½ lb., but this may be greatly exceeded, especially in the case of local races. It is a purely freshwater species, and more delicate in flavour than is usual with such forms.

The Smelt or *Sparling* (*Osmerus eperlanus*, fig. 1203).—This rather small fish is generally considered a dainty. It abounds in the tidal parts of many of the rivers of Europe and North America, ascending these for some distance for the purpose of spawning. Gunther says of it (in *The Study of Fishes*).—"In the sea it grows to a length of 8 inches, but, singularly, it frequently

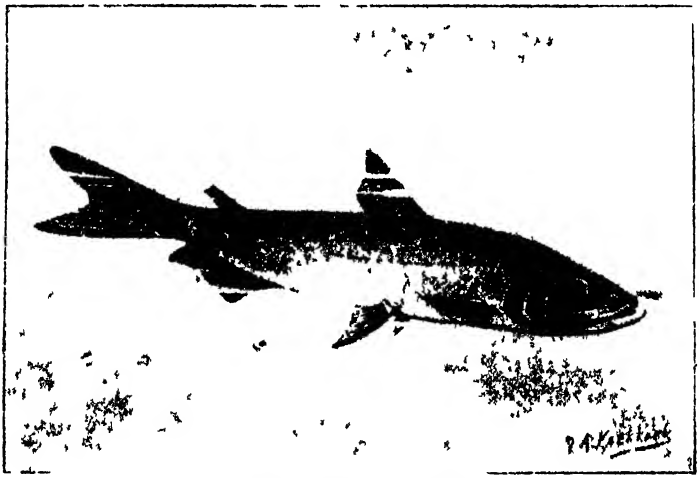


Fig 1203.—Smelt (*Osmerus eperlanus*)

migrates from the sea into rivers and lakes, where its growth is very much retarded. That this habit is one of very old date is evident from the fact that this small freshwater form occurs and is fully acclimatized in lakes which have now no open communication with the sea." Smelts are taken in large numbers by seines in some of the English estuaries which open into the southern part of the North Sea.

There are several other families of ordinary bony fishes (Teleostei) of which the freshwater species are used as food, such as the Carp Family, Pike Family, &c. As, in this country at any rate, they are of no particular economic importance, it is scarcely necessary to deal with them here. A few words, however, about a few of the families of lower fishes will not be out of place.

Those of most note include Sturgeons, Skates and Rays, and Lampreys.

THE STURGEON FAMILY (ACIPENSERIDÆ).—This belongs to an ancient group of Fishes (Ganoidei), closely related to the ordinary bony type. There are about twenty species of Sturgeon, all inhabiting the temperate part of the Northern Hemisphere. Like Salmon, they ascend rivers to spawn, and also in some cases for wintering, and some of them are altogether confined to the waters of the land. The Common Sturgeon (*Acipenser sturio*, fig. 1204) belongs to the British fauna, for it enters some of our rivers, as

Fig 1204.—Common Sturgeon (*Acipenser sturio*)

the Severn and Thames, and, being the property of the Crown, is known as a "royal" fish. Though perhaps 6 feet may be taken as the length of an average adult, a much larger size—up to about 12 feet—may be attained. The species is found on both sides of the Atlantic, on the one side entering the rivers of the Eastern United States, and on the other those of West Europe and the Mediterranean. It is absent from the Black Sea. The much smaller but more esteemed Sterlet (*A. ruthenus*) is native to the rivers that debouch into the Black and Caspian Seas, and also inhabits the Siberian rivers. It does not, as a rule, descend into salt water. The Giant Sturgeon or Hausen (*A. huso*), on the other hand, is much larger than the common species, but somewhat coarse. It lives in the Black Sea, Sea of Azov, Caspian, and the corresponding river basins. Güldenstädt's Sturgeon (*A. Güldenstädti*) ascends the rivers of the Black Sea.

So far as Europe is concerned, the sturgeon-fishery is of most

importance to Russia. The flesh of all the species is used as food, the hard roes (ovaries) are cleaned and salted to figure as caviare, to the extent of some 10,000 tons annually, and isinglass is prepared from the swim-bladders. For all these purposes the smaller sorts of Sturgeon, especially the Sterlet, are most esteemed. The Volga fishery is on the largest scale, and goes on at two seasons, autumn and winter. During the former, ground-lines with numerous hooks are used, and operations cease when the river begins to freeze. With increasing cold the fishes congregate at certain spots for hibernation, and such places are carefully marked by the fishermen. Later on, in January, when the cold is at its maximum, the winter-fishing is ushered in with great festivities. Good-sized holes are broken through the ice at the spots previously noted; the fishes, disturbed by the noise, come to the surface, and are promptly secured by means of harpoons and iron hooks.

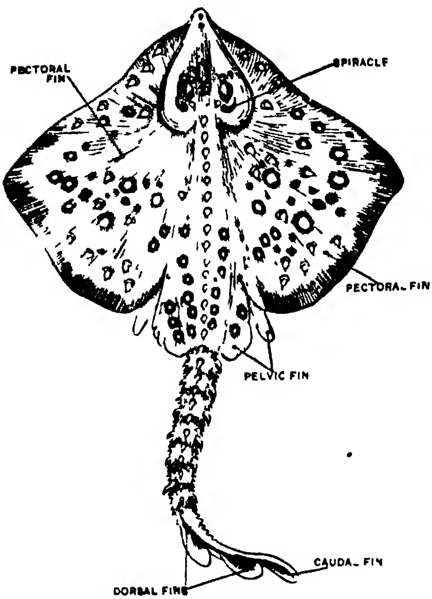


Fig. 1205. Thornback (*Raia clavata*)

SKATES AND RAYS (BATOIDEI).—These flattened, narrow-tailed, rhomboidal forms constitute, with Sharks, Dog-fishes, &c., the great group of cartilaginous fishes (Elasmobranchii). The two most important British species are the comparatively smooth-skinned Skate (*Raia batis*) and the Thornback (*R. clavata*, fig. 1205), of which latter the characters are sufficiently indicated by the name. The Skate may attain a length of 6 feet or more, and the Thornback about half as much. Both are common in British waters, where they are captured by trawling and by line-fishing. Though not among the choicer food-fishes, they are largely eaten, the enormous pectoral fins, cut into strips and rolled, constituting what is commonly known as "crimped skate".

ROUND MOUTHS (CYCLOSTOMATA).—The eel-shaped scaleless

Lampreys, which can be only called fishes by courtesy (see vol i, p 291), are considered great delicacies in some Continental countries, but are not abundant enough in Britain to be of economic importance The best known of our three native species are the Sea Lamprey (*Petromyzon marinus*), which may grow to the length of 3 feet, and the much smaller River Lamprey or Lampern (*P. fluviatilis*) less than half that size, both of which are marine forms that ascend some of our rivers to spawn the Severn

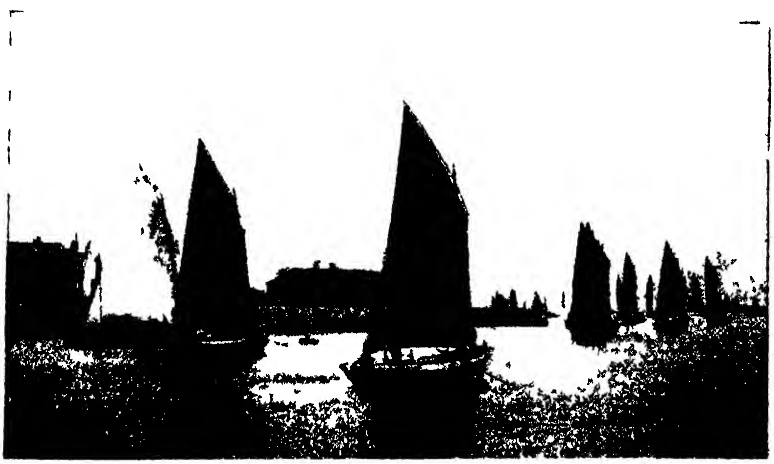


Fig 1206 Herring Boats leaving Aberdeen Harbour

being especially notable in this respect In *Cassell's Dictionary of Cookery* the following remarks are made about the lamprey, apparently the large species — This not very wholesome, but rare and rich fish, was a great favourite in ancient times, and is well known to the student of English history, as it was an attack of indigestion, brought on by eating of it too freely, which caused the death of Henry I Probable cost uncertain lampreys being seldom offered for sale '

FISHERIES

In practical fishery matters a distinction is drawn between "wet ' fish, *i e* fishes proper and shell fish among which both molluscs and crustaceans are included We are here for the present concerned with the former only (except as regards some of

the statistics). The importance of the matter to this country may be realized by giving a few figures.

In 1901 the number of fishing-boats registered in the United Kingdom (including the Isle of Man and Channel Islands) was as follows:—First class (15 tons or more), 7083, second class, 14,067; third class, 4647; total tonnage, 302,188. And to this must be added a large number of unregistered boats, chiefly of the third class. During the same year 68,878 persons were regularly employed in fishing, and 37,599 more found occasional employment.

The amount and value of the British catch for 1902 were as follows:—

Wet Fish.			Shell Fish.		
	Quantity in Cwts.	Value		Number.	Value
		£			£
Soles	76,624	512,596	Crabs	8,680,645	79,968
Turbot	64,094	245,215	Lobsters	1,632,110	73,317
Other prime fish	33,184	81,550	Oysters	43,482,711	119,086
Cod	1,584,528	865,934	Other shell fish	cwts. 613,436	138,544
Haddock	2,941,264	1,787,942			
Herrings	8,437,566	2,531,912			
Ling	252,627	115,925			410,915
Mackerel	599,983	390,321			
Sprats	76,066	16,636	Total Value of British Catch for 1902, £9,707,013.		
Whiting	403,247	161,392			
Other fish	3,432,862	2,586,675			
	17,902,045	9,296,098			

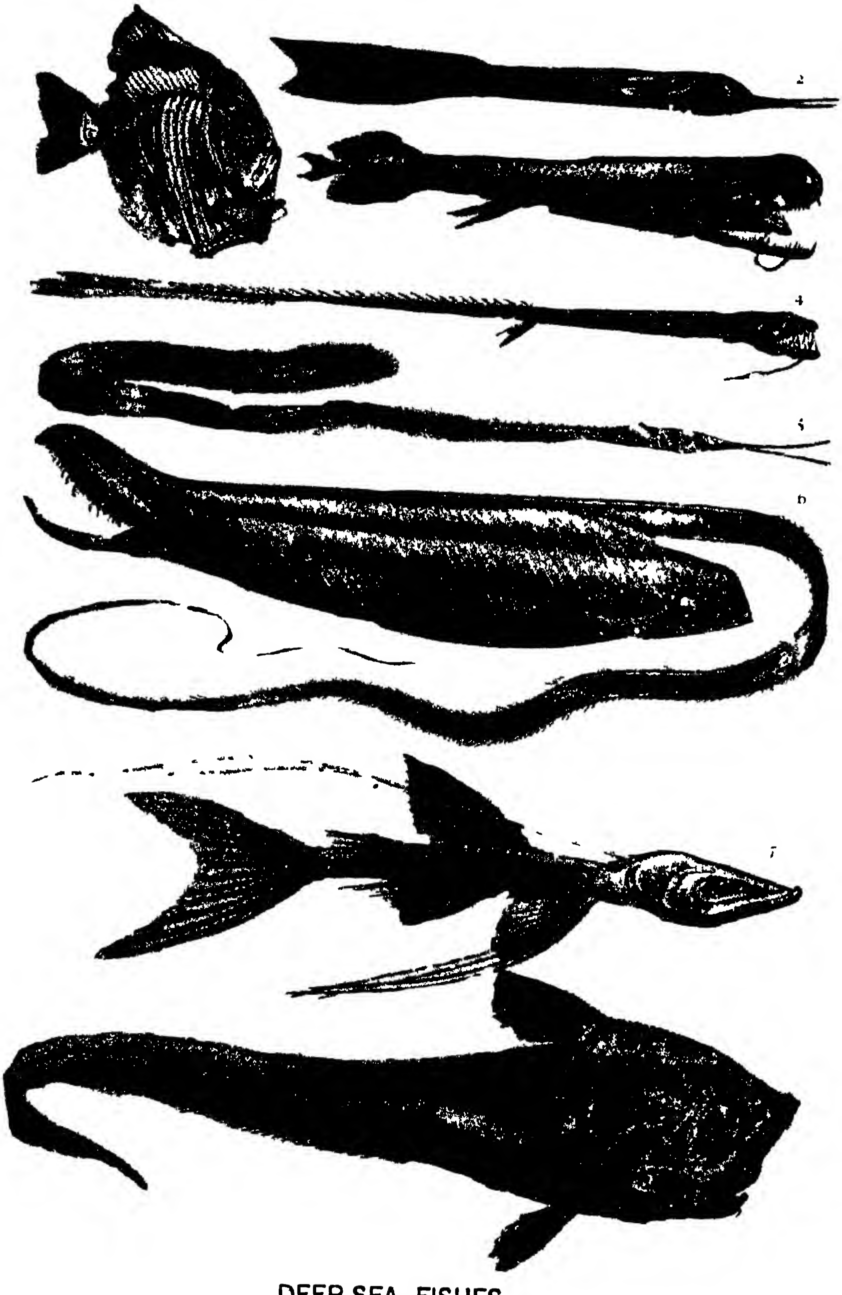
We do not entirely rely upon the British fishing industry for supplies, for in 1902 our imports of fresh and cured fish amounted to 2,587,370 cwts., valued at £4,105,800. Of this amount, however, 439,773 cwts. (worth £809,322) were re-exported, while we exported a part of our own catch to the value of £3,706,002, which included 2,249,976 barrels of herrings, worth £2,933,864. Of the exported herrings no less than 1,364,613 barrels were cured in Scotland, and the greater part of these were for Russian consumption, some of them finding their way as far east as Vladivostock.

During the last few decades it has gradually been realized by maritime nations that the supply of fish is not inexhaustible, and

DEEP-SEA FISHES (drawn to various scales)

The fishes of the deep sea are highly carnivorous forms, often provided with formidable teeth. The eyes are either very large or else greatly reduced. Luminous organs are often present. Many of these fishes are of bizarre appearance, as may be gathered from the plate, which represents eight species, as follows:—

1. *Sternoptyx diaphana*. small and translucent, with rounded luminous organs on the sides of head, body, and tail.
2. *Cyema atrum*. a small deep-sea eel, with reduced eyes.
3. *Malacosteus Indicus*: very large eyes, two luminous organs on the side of the head, and enormous mouth.
4. *Idiacanthus ferox*· a greatly attenuated form, with numerous small rounded luminous organs on the side of the body.
5. *Nemichthys ingens*: a greatly elongated deep-sea eel, with large eyes, and jaws drawn out into a slender beak.
6. *Saccopharynx ampullaceus*: a large deep-sea conger-eel, which has succeeded in swallowing a fish much bigger than itself.
7. *Bathypterois longicauda*: a deep-sea fish with reduced eyes, and much elongated fin-rays serving as feelers.
8. *Macrurus crassiceps*: a species of a widely distributed deep-sea family related to that including the cod, &c. Eyes extremely large, and mouth on the under side of the head.



DEEP-SEA FISHES

DRAWN TO VARIOUS SCALES

this is partly due to the steady increase of steam-trawling, which means capture on a wholesale scale. Practical men are recognizing more and more that expert scientific advice must be requisitioned if the supply of fish is to be maintained, and still more so if it is to be increased. As Cunningham very justly remarks (in *Marketable Marine Fishes*):—"It can scarcely be expected that the fisherman or fish merchant will spend his short and hard-earned leisure moments in the study of the blue-books and technical memoirs in which the results of research are described; and when certain newly-established facts are brought before them in other ways it frequently happens that they either deny these facts, as contrary to their own experience, or turn a deaf ear, from the conviction that such matters are of no practical importance. With reference to the contradiction of the naturalist's conclusions, it may be urged that, although he may not be able to climb the rigging of a smack, and is generally sick while at sea, although also he may be as ignorant as a baby of the mysterious and complicated practice of the fish-trade, still he has two advantages over the professional fish-man in attempting to get at the truth concerning the life and habits of fish. Firstly, he has been trained to appreciate the value of scientific evidence, and is on his guard against jumping at conclusions; secondly, he can use instruments of precision, which are as essential to the investigation of some of the matters in question as the compass and the lead to the handling of a fishing-vessel. With regard to the practical importance of the naturalist's researches and results to the fishing industry, it can only be said that there is no doubt about it. It is an undeniable fact that parliamentary legislation and local by-laws are at the present time constantly being demanded or proposed for the benefit of the fisheries, and the reasons by which these proposals and demands are supported consist largely of statements concerning the natural history of the fishes and other marine creatures concerned. It is necessary, therefore, that we should be able to test the correctness of these statements, and should be able to judge correctly of the most probable effect of the measures proposed on the productiveness of the fisheries."

A few epoch-making dates in fishery work may here be appended with advantage, and the reader may draw his own conclusions as to the relative enterprise displayed by the nations concerned. 1862, Professor Allman of Edinburgh investigated

the spawning of herrings at the request of the Scottish Fishery Board. 1864, Professor Sars of Christiania commissioned by the Norwegian Government to investigate the natural history of the cod and the cod-fisheries of the Lofot Islands. 1870, the Prussian Minister of Agriculture instituted a Commission for the Investigation of the German Seas. 1871, institution of the United States Commission of Fish and Fisheries. 1882, establishment of the new Fishery Board for Scotland; this marked the first commencement, on a large scale, of the application of scientific methods to British fishery problems. 1884, inauguration of the Marine Biological Association of the United Kingdom (active work at the Plymouth Marine Station commenced in 1887) on the initiative of Professor Ray Lankester. The late Professor Huxley was the first president. In the same year the marine laboratories at St. Andrews and Granton (near Edinburgh) were completed. 1886, a Fishery Department of the Board of Trade was organized, but without power to make scientific investigations. 1899, an annual sum of £10,000 was devoted to Irish Sea-Fisheries. More recently the countries interested in the fisheries of the North Sea have agreed to jointly investigate that area with regard to fishery problems on scientific lines. In 1901 the Board of Trade appointed a Committee on Ichthyological Research, with the view of ascertaining the best methods of carrying out scientific investigations of problems affecting British fisheries. The committee presented their report in the following year, suggesting greatly increased expenditure, with a view to solving certain pressing problems, and recommending, among other things, the establishment of a Fishery Council for England.

Some varieties of fishery work which are of special importance may now be very briefly indicated.

Statistics.—Until we know with some approach to definiteness the amount of each kind of fish captured yearly, together with the time, place, and method of capture, it will be impossible to form a sound opinion as to whether the natural supply is actually diminishing generally or locally.

Habits and Life-Histories of Food-Fishes.—It is clear that full knowledge on these points is absolutely necessary from the practical stand-point, for upon such knowledge must ultimately depend the various means adopted for regulating the fishing industry. Full information of the sort regarding any particular form, joined

to that derived from statistics, would enable us to determine with a reasonable approach to accuracy the best methods, times, and places for capturing such fish, securing on the one hand a profitable result, and on the other hand obviating wasteful depletion of the natural supply.

Food of Fishes.—Directly or indirectly the most important source of fish food is found in "plankton", *i.e.* the various floating organisms which are found in vast numbers at or near the surface of the sea (and of lakes). Minute plants, animalcules, small crustaceans (especially Copepods), various larvæ, and floating eggs (including those of fishes themselves) are among the more important constituents. Some valuable food-fishes, such as the herring, feed solely on plankton.

The amount of this food available bears a direct relation to the fish-supply, and Professor Hensen of Kiel has devised ingenious and elaborate methods of estimating it in a quantitative manner. Details cannot be given here, but the following extracts from a paper by J. Travis Jenkins (*The Methods and Results of German Plankton Investigations*) will serve to give some idea of the importance of the matter:—"The plankton estimation methods of the Germans, the credit for initiation of which is due to Hensen, differ from and mark an advance upon the methods hitherto employed in England, inasmuch as no attempt is made in the latter country to arrive at a quantitative as distinguished from a qualitative result. The questions that Hensen attempts to answer are—(1) What does the sea contain at a given time in the shape of living organisms in the plankton? and (2) How does this material vary from season to season and from year to year? It may be pointed out that the results obtained by the German investigators are largely due to the liberal attitude taken by their Government with regard to subsidizing scientific investigation of problems connected with the sea-fisheries. It is to be hoped that the Irish Sea may be subsequently investigated in like manner. A comparison with the results already obtained for the North and Baltic Seas could not fail to be of interest and to yield important results." Some of the most striking estimations were made on the number of Fork-footed Crustaceans (Copepoda) in plankton, since it is these which constitute the chief food of herrings, sprats, and their allies. The following results were yielded by the method:—"For a square mile of surface-water the annual consumption of Cope-

poda can be regarded as approximately 975 billion, or for the 16 square miles of the Eckenförde fishery district [in the West Baltic] a grand total of 15,600 billion. A billion Copepoda yield not less than 1500 kilograms of dry organic substance, so that the 15,600 billion weigh not less than 23,400,000 kilograms [*i.e.* more than 22,982 tons]. Taking the average weight of an adult West Baltic herring as being 60 grams, and allowing that every herring uses in fifty days its own weight of organic substance, we find that every herring consumes annually 438 grams. In the 16 square miles of the Eckenförde fishery district there exists food in the shape of Copepoda for 534,000,000 herring of an average body weight of 60 grams. This result may, of course, be largely problematical, but it is at any rate extremely interesting. The North Sea, in a similar manner to the Baltic, contains an abundant wealth of Copepoda. The open ocean, on the other hand, contains much less." The number of floating fish-eggs of a particular kind contained in plankton may be used as a basis for determining the number of fish of the sort present in a given area at a given time. Applying this method to the cod and plaice of the Eckenförde, Hensen estimates that "man captures for his own use every year about one-fourth of the total number of adult fish in this particular area of the West Baltic. This result is surprising to those who consider the resources of the sea as inexhaustible, and believe that the number of fish caught by man bears only a small proportion to the number actually present in the sea." It is also interesting to learn that the northern seas are richer in plankton than those in warmer latitudes. The possibilities of the Hensen methods are thus seen to be very considerable, but it is unsafe to generalize from a small number of determinations, for the distribution of plankton in a given area is by no means uniform. In this, and many other matters involving accurate scientific research, large government subsidies are urgently needed in this country. We are co-operating, it is true, with other nations in a scientific survey of the North Sea for the space of three years, but during that period the annual grant of £2000 per annum to the Scottish Fishery Board is suspended, thus seriously crippling an organization that has long been engaged in work of the most valuable kind.

FISH-CULTURE (PISCICULTURE).—The rearing of fishes in ponds is a very ancient art, which was practised by the Egyptians,

Greeks, and Romans, of antiquity. The young of various species were made to enter lagoons, prevented from again escaping, and kept till large enough for the table. Culture in freshwater ponds has been an important Chinese industry from time immemorial, and was well understood in England during the Middle Ages, especially by the monks, who did not care to rely on chance for the periodic fish repasts prescribed by the Church. Remains of old "fish-stews", in which carp, eels, &c., were reared, abound in this country.

A very interesting outcome of the fish-culture of the old Romans still exists in the lagoon of Comacchio, at the mouth of

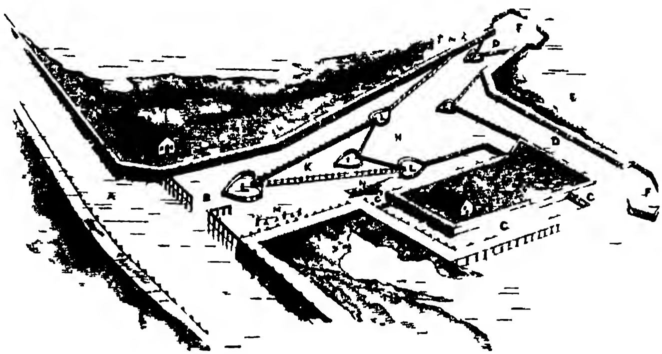


Fig. 1207.—A Division of Comacchio

A, Canal Palotta. B, Entrance from canal. C, Canal for boats. c, Sluices. D, First compartment of labyrinth. E, Outer basin. F, Antechamber of first compartment. G, Chamber of ditto. H, Second compartment. I, Chamber of ditto. K, Third compartment. L, L, L, Chambers of ditto. M, Wicker-work baskets for keeping fish alive. N, Boat and tackle. O, Dwelling house. P, Storehouse.

the Po, where eels are grown on a large scale, and distributed throughout Italy both fresh and in a preserved condition. The definite records of the industry date from 1229, and so long ago as the end of the sixteenth century the annual revenue derived from the culture amounted to £16,000 annually, a sum which, of course, represented much more at that time than it does now. The eels sold in 1903 fetched over £28,000. The whole lagoon, which is bounded at the sides by the Reno and Volano mouth of the Po, is a perfect labyrinth of ponds and canals, of which a faint idea may be gained by examining fig. 1207. The conduct of this industry is a very elaborate matter. The ascending swarms of eivers have to be guided to their destination, the supply of fish-food maintained, full-grown eels captured (from August to December), and the catch prepared for the market.

The pond-culture of Carp is carried on in a very systematic manner in some parts of Germany, and it need only be said that the fish are transferred from one pond to another according to age.

The discovery of the possibility of artificial fecundation, by mixing eggs and milt together, constituted an epoch in fish-culture which opened up far-reaching possibilities the importance of which has only been fully realized of late years. It appears to have been first practised, for salmon and trout, by S. L. Jacobi of Hohenhausen, in Westphalia, so long ago as 1748, and was continued by him and his sons, with profitable results, till 1825. George III (of England) gave a pension to Jacobi in 1771.

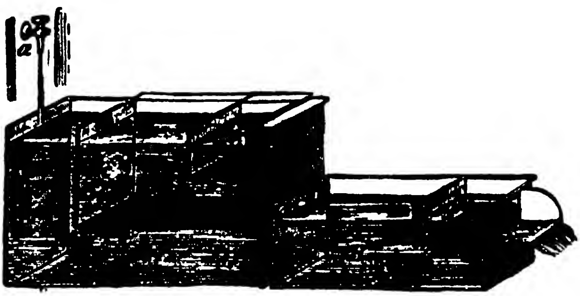


Fig. 1208.—Staby's Californian Trough

A, Hatching tank, into the outer part of which (*b*) water flows from a tap (*a*), *c* and *d* are hatching trays with floors of fine wire-gauze; *e*, outflow. *B*, Tank to catch fry which escape from *A* when *d* is removed; they pass into the space *f*, but are prevented by the gauze partition *g* from getting washed away in the outflow to the right

Scotland, as usual, was one of the first of other countries to profit by an improvement on old methods, for we find that in 1837 John Shaw, a gamekeeper at Drumlanrig of the Duke of Buccleuch, introduced Jacobi's system. But the beginning of fish-culture on a national scale only dates from 1850, when the French Government instituted a large fish-hatching establishment at Huningue, in Alsace. At the present time America has profited most by the pursuit of fish-culture, which is largely practised with reference to their rivers and lakes. One type of hatching apparatus suitable for trout and salmon is represented in fig. 1208 as constructed by Dr. Ludwig Staby, and named by him "the deep Californian trough".

The fact that most marine fishes lay floating eggs renders fish-culture in their case comparatively easy, for any quantity of fertilized eggs can be collected from the surface of spawning-ponds

in which adult fishes are confined. In a hatchery for such fishes the eggs are placed in various receptacles, where they are kept aerated by suitable devices. MacDonald's hatching-bottle (fig. 1209) is largely employed in the United States for the small eggs of shad and other fishes, of which one bottle will accommodate about 70,000.

An important hatchery for cod has for some years been in operation at Flödevig, near Arendal, in Norway, under the superintendence of Captain Dannevig. In Scotland there is an important hatchery, chiefly used for plaice, connected with the marine station at Nigg, near Aberdeen, and there is also one at Piel, on the coast of Lancashire. There are, of course, important hatcheries for marine fishes in America.

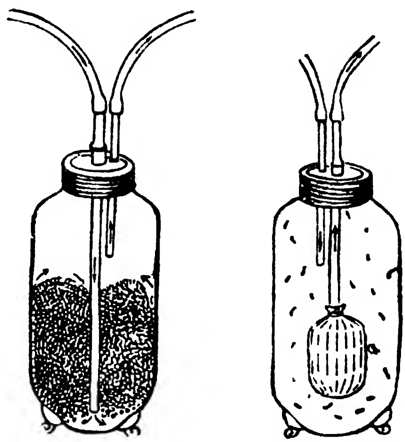


Fig. 1209.—MacDonald's Hatching Bottle. The one on the left is arranged for hatching purposes, and the other contains fry. Course of water indicated by arrows.

Regarding the value of hatcheries for freshwater forms, and fishes which, like the salmon, spawn in rivers, there can be no doubt. As to marine fish-hatcheries, which aim at maintaining or even increasing the supply by liberating great numbers of fry in the sea, the data are at present too incomplete to estimate their utility. It appears to be certain in some cases that good has been done by them, one instance of the sort being afforded by the Norwegian hatchery near Flödevig, but the expense involved is considerable, and for some species and some localities may well turn out to be so great as not to be justifiable. The large majority of the just-hatched fry which are now from time to time placed in the sea are destined to perish before growing to a marketable size, and it may in the end turn out to be necessary to carry the culture to a stage which will give a greatly increased chance of survival. But this is notoriously difficult, and a large amount of experiment is necessary before success is likely to be attained. And even in the event of the various obstacles being surmounted, the greatly increased expense of such a method may prevent its adoption.

There is a second possibility of exactly opposite kind, suggested by Cunningham, *i.e.* to give up hatching, and largely increase the extent of spawning-ponds, contenting ourselves with setting adrift vast numbers of fertilized eggs. Both the possibilities mentioned require testing on a large scale, and afford suitable objects for large Government expenditure. The money spent on a single battle-ship, or even on a cruiser, if devoted to this purpose, would quite conceivably settle the whole vexed question of British marine fish-hatcheries so far as some of the more important food-fishes are concerned. And unless scientific research, both pure and as applied to our important industries, fisheries of course included, is not far more largely endowed in future than it has been in the past, it may come about in the course of time that the country will be unable to afford a sufficient number of battle-ships, cruisers, and similar expensive necessaries.

MOLLUSCS (MOLLUSCA) AS FOOD

Brief mention has already been made (see p. 214) of various molluscs used for food in different parts of the world. A few of these are of such importance that they require somewhat more detailed treatment. They are Oysters, Mussels, Cockles, and Periwinkles.

The Oyster (*Ostrea*).—The most important European species is the "Flat" Oyster (*O. edulis*), to which our "natives" belong. There is also the large, somewhat triangular, Portuguese Oyster (*O. angulata*), which is of considerable economic importance, though of coarser kind. The American Oyster (*O. Virginiana*), commonly known in this country as "blue point", is the object of valuable and extensive fisheries on the Atlantic coast of the United States. In spite of typhoid scares it is probable that oysters will continue to be popular delicacies in this country, those from Whitstable and other fisheries in the Thames estuary being most esteemed.

Oyster Culture.—Some nations engage on a large scale in oyster culture as well as oyster fishing. Italy, Holland, France, and the United States may be particularly mentioned in this connection. This kind of culture mainly depends on the fact that the larvæ, fry, or "spat" readily attach themselves to various foreign objects, and can then be reared to "seed"

oysters, which may be further grown where produced, or else despatched elsewhere. The practice varies largely in different countries, and perhaps the most interesting case is afforded by France. It may be remarked in passing that the Italian oyster-industry has existed continuously from the times of the ancient Romans, and that the oysters are commonly grown upon bundles of twigs (*fascines*). The Dutch largely employ earthenware tiles, and the numerous estuaries of Holland afford suitable localities.

The large development of oyster-culture in France during the last few decades is very remarkable, and is the outcome of some experiments made in 1853 by M. de Bon, commissaire of marine at St. Servan. At that time the natural oyster-beds of France had been so much depleted by over-dredging that not only was strict legislation regarding them necessary, but the question of future supply naturally demanded attention. The observer mentioned found that the oyster-fry readily attached themselves to pieces of stone or stick, and this was the first step in the evolution of "collectors" to serve this end. The earliest attempts to revive the industry by artificial culture were unfortunately not successful, but many natural obstacles were gradually overcome, the final result being a flourishing and highly-specialized trade, in which there is much division of labour. The total annual value of the industry considerably exceeds half a million pounds sterling. In 1902 the fresh oysters imported into this country from France were worth £30,000.

Public dredging of the natural oyster-banks of France is so stringently limited by Government that they are of little importance as regards the direct supply of the market. They are, in fact, regarded as a reserve of spawning individuals, by which vast quantities of spat are produced. One important branch of the industry is to catch the spat on collectors ingeniously adapted to the conditions of particular localities. Some of these devices are made of boards, fixed together in successive tiers; but most of them consist of curved earthenware tiles, arranged in wooden crates, wired together, or otherwise associated (fig. 1210). Whatever their precise nature, they are mostly to be found fixed in their appointed places near low tide-mark or in shallow water, by the beginning of July, *i.e.* at the time when the fry are liberated from between the shells of the parent oysters. The tiles (or boards) have previously been covered

with a thin layer of a mixture of lime and sand (or mud), and it is the under surfaces which, under ordinary circumstances, serve for the attachment of the larval oysters when these give up a free-swimming existence for a sedentary life. It may be added that in some localities it has been found possible to construct large spawning-ponds instead of relying on the supply of spat from the oyster-banks off the shore.

Fig. 1210.—The Gabarét Collector (Ruche) in position (at Arcachon). Young oysters are seen attached to the tile which is being lifted, and to another that is up-ended on the right. The collectors are covered with sea-weed, so that when left by the tide they are kept moist, and protected from heat and light.

A "set" of spat having been secured on the collectors, the tender molluscs are left till about October, by which time they have grown to the size of a finger-nail, and are known as "seed-oysters". They are then flaked off the tiles (or boards), which the thin layer of lime renders possible with trifling loss, and carefully packed. This ends the stage of production (*production*), and the little oysters are now committed to the care of another set of specialists, who rear them to a marketable size. This process of *élevage* is much more difficult. The *éleveur* places the seed in rectangular rearing-cases, the upper and lower sides of which are chiefly made of wire-gauze. As

growth proceeds, sorting from time to time becomes necessary, so as to give increased room. The cases are placed in oyster "parks", which are simply enclosed areas of shallow water, with boundaries of the most various character, from lines of waving saplings to solid masonry pierced by flood-gates (fig. 1211). When the oysters have attained a fair size they may be trans-

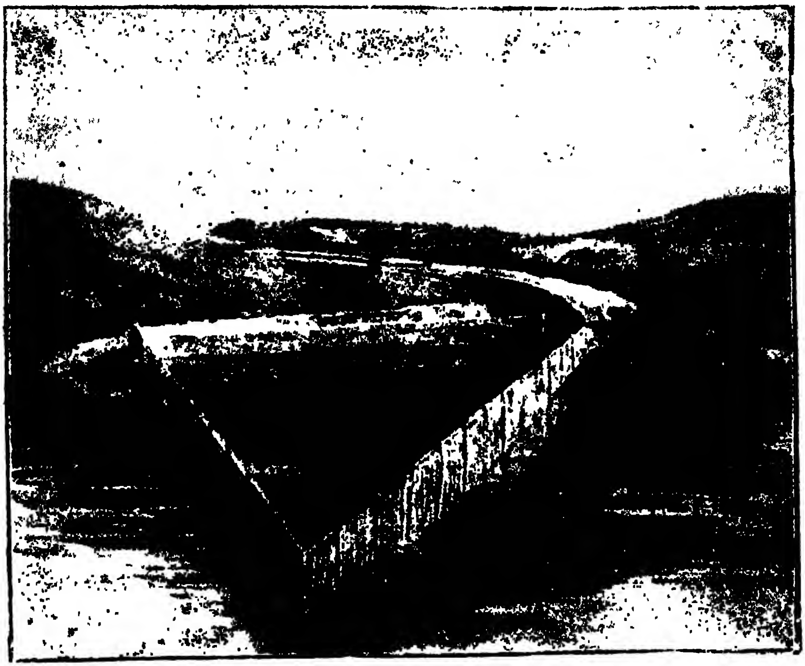


Fig 1211.—A Norwegian Oyster-Park

ferred from the cases to the floor of the park, which sometimes has to be specially prepared for their reception.

There are still two more stages which some French oysters have to go through before they reach the market. One is the process of "greening", as at Marennes, the products of which are greatly esteemed. The oysters are here kept for a long time in small and muddy salt ponds (*claires*), where they gradually acquire a green colour owing to the nature of the food available, which consists of minute algæ. At the same time a peculiarly delicate flavour is imparted. Healthy British oysters from the estuaries of the Roach and Crouch, in Essex, may also be

green, and for the same reason. Certain green oysters, however, should be looked upon with suspicion, as, for example, some of those from Cornwall, in which the colour is due to the presence of copper.

The last process to which some of the French oysters are subjected is that of education for transport. They are gradually accustomed to be out of water, and to close their valves closely, which clearly enables them to be sent in a good condition for long distances.

English Oyster-Industry.—That this industry is of considerable importance will already have been gathered from the statistics on page 280. We may take as an example the Whitstable Oyster Fishery Company, which is one of the most notable. As to its yield of oysters, the Secretary of the Company, Mr. W. H. Reeves, writes in a private letter: "With regard to statistics I can only say that our own sales of oysters average about 10 million to 12 million yearly, and of this number about two-thirds are English Natives and the rest imported from France, with a small percentage of East River oysters from America".

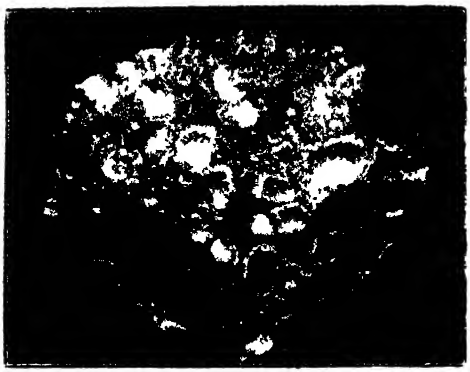


Fig. 1212.—Shell of a Whitstable Native, with young Oysters attached Reduced.

As most persons are aware, Whitstable is on the north coast of Kent, east of the Isle of Sheppey, and has been an important seat of the oyster-trade from very remote times. The details here given are derived from a book by A. O. Collard (*The Oyster and Dredgers of Whitstable*), to which readers are referred for further information. The following quotation from this book will give an idea of the length of time for which "natives" have been popular:—"Among some valuable notes attached to the evidence taken on oath in the Committee of the House of Lords in 1866, on certain bills promoted by the Herne Bay Fishery Company, I find the following observations: 'The Whitstable Company are a most ancient body of 'free fishers

and dredgers', who, from father to son, have carried on the business of an oyster fishery during, it is probable, a period of

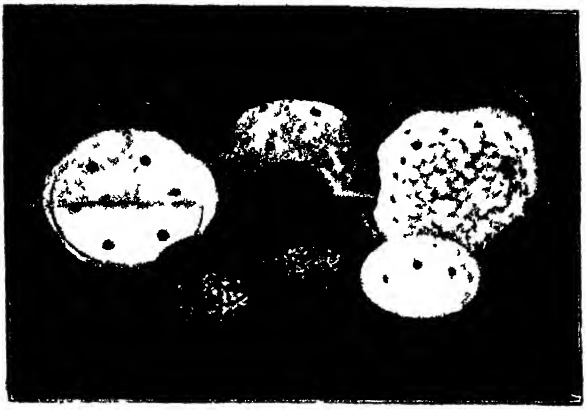


Fig 1213.—Wheeler's Beehive Collector Much reduced

at least two thousand years. It was about A.D. 80 that Julius Agricola first exported oysters from the neighbourhood of the

Fig 1214 —Whitstable Oyster-Dredger at work. Dredges on the rail

Reculvers to Rome, and for the ancestors of the Whitstable free dredgers Rome was, during about three centuries, their

Billingsgate.' . . . When we remember what is known of the early state of Great Britain, we can scarcely be surprised that Sallust, who lived and wrote about fifty years before Christ, had a better opinion of our oysters than our ancestors, for he said, 'The poor Britons—there is some good in them after all—they produce an oyster'. Whitstable may certainly claim some share in creating that good impression."

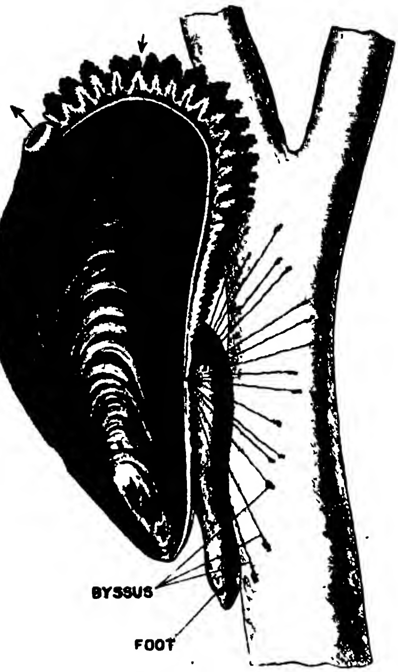


Fig 1215.—Edible Mussel (*Mytilus edulis*)

The superior quality of the Whitstable Natives is mainly due to the character of the in-shore beds where the oysters live, for not only is the soil favourable, but there is the necessary admixture of fresh water of suitable nature from the land. Upon these beds are planted the seed oysters dredged further out in the estuary, while some of these are imported from France. The "cultch" to which the bivalves attach themselves is largely made up of empty oyster-shells (fig. 1212). One ingenious method that has been tried for catching the spat is by means of Wheeler's Beehive Collector (fig. 1213), made of perforated earthenware, and partly filled with empty shells. Space forbids reference to the way in which the mature natives are treated after they have been dredged (fig. 1214) and before they are finally packed in barrels for the market.

The Edible Mussel (*Mytilus edulis*, fig. 1215).—This mollusc is used to a considerable extent as human food, though there is rather a prejudice against it on account of the fact that occasional batches turn out to be poisonous, causing serious illness or even death. That mussels are nevertheless eaten largely in England may be deduced from the fact that in 1902 no less a quantity

INTERTIDAL AND SHALLOW WATER ANIMALS

The plate represents a tide-pool on the British coast, and introduces a number of familiar marine animals. Beginning with those lowest in the scale they are:

1. Sea-Anemones (*Actiniæ*).
2. Common Star-fish (*Uraster rubens*).
3. Acorn-Barnacles (*Balanus*).
4. Shore-Crab (*Carcinus mænas*).
5. Cockles (*Cardium*). The one on the left belongs to the edible species (*C. edule*).
6. Sea-Mussels (*Mytilus edulis*).
7. Scallop (*Pecten*).
8. Periwinkles (*Littorina*). Those on the right are of the edible sort (*L. littorea*), while the small yellow ones on the left belong to another species (*L. obtusata*).
9. Purple-Shells (*Purpura lapillus*).
10. Gulls (*Larus*).

A TIDAL POOL WITH FAMILIAR MARINE ANIMALS

1. Sea-Anemones. 2 Star-fish. 3. Acorn-Barnacles. 4 Shore-Crab. 5 Cockles.
6 Sea-Mussels 7 Scallop. 8 Periwinkles 9 Purple-shells. 10. Gulls.

than 43 tons 10 cwts. of them was seized and condemned at and near Billingsgate Market. On the Continent the consumption is much greater than with us.

The mussel is greatly valued as a bait in British line-fishing, particularly on the coast of Scotland. The yield in that country for 1902 amounted to 95,663 cwts., valued at £5445, which contrasts strongly with the 247,186 cwts., worth £14,506, collected in 1892. The meaning of the steady diminution which has been going on for some years has reference to the displacement of line-fishing by trawling. The same thing has been happening with regard to "clams" (species of *Pecten* and various other bivalves), another valuable bait in Scottish line-fishing. The quantity of clams taken in 1892 was 20,769 cwts. (£2736), but in 1902 only 4320 cwts. (£586).

Mussel-Culture. As in the case of the oyster, the eggs hatch out into free-swimming "fry", which after a time attach themselves to various objects, not, however, by the substance of one valve, but by silky byssus threads. Nor is the mussel obliged to spend the whole of its fixed life in one spot, for it can cast off the threads, and crawl away to some distance, if adverse circumstances render a change of residence desirable. Important musselries were established some years ago at Montrose, and previously barren ground was made very valuable. The principle involved essentially consists in reserving certain beds for the production of "seed", as in the case of the strictly-preserved natural oyster-banks on the French coast (see p. 289). From these beds the young mussels are collected and planted out on other areas.

On the Baltic coast of Germany tree-branches are thrust into the sea-floor in shallow water (fig. 1216), serving as collectors for the fry, which grow upon them to a marketable size. After from three to five years they are pulled up, weighed, and sold with their living crop still adhering.

At some points of the French sea-board, especially at Esnaudes on the west coast, elaborate mussel-farming is practised, on what is known as the "bouchot" system. Each bouchot is a **V**-shaped or **W**-shaped collection of stakes driven into the mud, with the opening directed seawards. Adjacent stakes are connected by interwoven branches, and the 500 bouchots of the Esnaude musselry have a collective length of not far short of

130 miles. During the first two months of the year the mussel-fry attach themselves to the bouchots next the sea, and by May have grown sufficiently large to be scraped off without difficulty. They are then placed in small bags made of old canvas and the like, which are fixed to stakes further from the sea. Ultimately the bags rot away, leaving the mussels hanging in bunches by their byssal threads. As time goes on they are transferred further and further landwards, till by the time the

Fig. 1216.—Part of a Baltic Musselry

innermost stakes are reached they are large enough to gather for sale. The annual yield of Esnaudes is valued at not less than £52,000.

The Cockle (*Cardium edule*).—As a cheap, if indigestible, substitute for the oyster this bivalve is largely eaten by the populace in this and other countries. It burrows in the sand or mud of bays and estuaries, and is captured by raking at low tide. Morecambe Bay, Caermarthen Bay, and the estuary of the Teign are notable localities. Statistics for this country are not available, for even in the Reports of the Scottish Fishery Board the

cockle is an "unclassified" shell-fish. But most of us have seen small detachments of this mollusc displayed for sale on stalls, with vinegar and pepper as accompaniments, and have speculated as to what kind of customer might be expected. And we have the significant fact that, in 1902, 7 tons 18 cwts. 2 qrs. of cockles were seized and condemned at or near Billingsgate Market.

The Periwinkle (*Littorina littorea*).—The popular 'winkle is gathered between tide-marks on many parts of our coasts, the greater part of the London supply being derived from Scotland. The large quantity of 54 tons 5 cwts. was seized and condemned at or near Billingsgate Market in 1902.

CRUSTACEANS (CRUSTACEA) AS FOOD

We are here chiefly concerned with Lobsters, Prawns, Shrimps, and Crabs (fig. 1217), though these are far from being the only edible species.

The Lobster (*Homarus vulgaris*).—Of all large crustaceans this is the most esteemed in this country, and vast numbers are annually consumed. Along the rocky parts of the coast of the British Isles, Norway, Canada, and many other countries, lobster-fishing is a very important industry. A large part of the English supply is derived from Scotland, for which the yield in 1902 was 786,400, valued at £37,114. The home-supply is by no means equal to the demand, and our imports of lobsters, fresh and canned, are very considerable. Of the former we relied upon Norway for 38,538 (worth about £1850) in 1902, and upon France for many more. Lobster-canning is an important industry for Newfoundland, Canada, and the United States. It should be added that the American Lobster (*H. Americanus*) is not of the same species as our native form, though closely allied.

Lobsters are caught in "pots" or "creels", contrivances of the nature of traps, constructed of a wooden framework covered with netting (fig. 1218). Fish-entrails or other garbage is used as bait, the creel being sunk in a suitable spot by means of stones, a cord with a cork at the end serving to mark the spot.

Lobster-fishing has to be regulated with considerable stringency, as it is only too easy to deplete the supply. Hatching has

been carried on to a considerable extent in several countries with a view to maintain or, if possible, increase the numbers available. The difficulties to be overcome are far less formidable than in the case of fishes, for the female or "hen" lobster carries about her

Fig. 1217.—1, Common Prawn (*Palæmon serratus*). 2, Common Shrimp (*Crangon vulgaris*). 3, The Edible Crab (*Cancer pagurus*). 4, The Lobster (*Homarus vulgaris*).

eggs attached to the under side of the tail, at which time she is said to be in "berry". So long ago as 1887 Captain Dannevig, at the Norwegian fish-hatchery near Arendal, found it possible to rear lobster-fry from the eggs, and such rearing is now resorted to by Scotland, Canada, and the United States, among other countries. The Aberdeen hatchery, for example, liberated some

3000 minute lobsters during 1902. The value of these hatcheries is doubtful.

The Edible Crab (*Cancer pagurus*).—This savoury crustacean is also of considerable economic importance (see p. 280). The chief method of capture is the same as for the lobster. Hatching methods are here also being made the subject of experiment. The Aberdeen hatchery cast adrift in the open sea no less than 4,500,000 of juvenile crabs in the year 1902.

Shrimps and Prawns.—A Common Shrimp (*Crangon vulgaris*) is distinguished from a Prawn (*Palæmon serratus*, &c.) not only

Fig 1218.—Crab-Pots

by its smaller size, but also by several structural features, of which the most obvious is the absence of the sharp saw-edged spine which projects from the head of the latter. Prawns are often known as "red shrimps". The annual consumption in this country must be very large, judging from observation, and the fact that in 1902 shrimps (presumably including prawns as well) to the amount of over 54 tons were seized and condemned at or near Billingsgate Market. We also know that in the year mentioned over 900 fishing-boats (mostly second class) were engaged in capturing shrimps and prawns, chiefly by trawls, round the coasts of England and Wales. The catch of three small third-class Scottish trawlers working for that period in the Solway Firth was worth £3571, and if the earnings of the English boats were

proportionate the total value of their catch must have been very considerable. And we have further to consider the great army of shrimpers working by means of various kinds of hand-net (fig. 1219), or dragging similar contrivances along by means of carts.

Fig 1219 Shrimper working a Push Net

The Fresh-Water Crayfish (*Astacus fluviatilis*).—This inhabitant of many of our rivers and canals, which resembles a small lobster in appearance, is of no great economic importance to this country, although of decidedly delicate flavour. On the Continent however, an allied but larger species (*A. nobilis*) is much eaten

CHAPTER LXIX

ANIMAL FRIENDS—WILD ANIMALS CAPTURED FOR VARIOUS ECONOMIC PURPOSES—BENEFICIALS

The present section has mainly been concerned with the animal kingdom as a source of food, although in dealing with domesticated forms it has been found convenient to mention commodities of other kinds, such as wool.

We now have to deal with economic products other than food, for the sake of which wild animals of various kinds are captured. Prominent among these desiderata are furs, skins, fats, and oils, besides which there are a great number of less important articles of commerce, such as sponges and medicinal substances, that call for passing notice. Animal products employed entirely or mainly for decorative purposes will be reserved for treatment under Animal Æsthetics.

FUR-BEARING MAMMALS (MAMMALIA)

Although in temperate regions, as we have seen (p. 228), woven clothes have replaced for ordinary purposes the garments of skin and fur devised by prehistoric races, this by no means applies to the colder parts of the world, where ordinary clothing does not afford sufficient protection from the rigorous climate. The nomad tribes of the Russian steppes, for example, make large use of such garments, and the heathen Ostiaks of North Siberia do so to a still greater extent (fig 1220). Of the latter Brehm says (in *North Pole to Equator*) that " they use nothing but the skin of the reindeer for clothing, and only employ the furs of other animals for the occasional decoration of the reindeer, or, as the Russians call them, stag skins Their dress consists of a close-fitting skin coat reaching to the knee, in the men it is slit down the breast, in the women it is open down the whole front, but held together with leather thongs, a hood of the same material is

usually attached to or forms part of the dress; mittens also are sewn on, leather breeches reach below the knee, and leather stockings, which fasten over the knee, complete the attire. The fur garment worn by the women is edged down the sides of the

Fig 1220—Heathen Ostiaks

opening with a carefully-pieced border of variously-coloured little squares of short-haired fur, and always has a broad band of dog-skin round the foot; that worn by the men has at most a border of dog-skin round the foot; the leather stockings, if they are decorated at all, are composed of many prettily-combined, diversely-coloured stripes of skin from the leg of a reindeer, with a stout

shoe partly sewn on, partly laced over the foot." The Esquimaux dress is spoken of elsewhere (see p. 227).

That we ourselves have not altogether abandoned the dress-materials of our remote prehistoric ancestors is sufficiently attested by the fact that in 1902 over 97,000,000 skins and furs, worth £5,578,452, were imported into this country, though of course only a part of these were destined for personal wear.

The list of fur-bearing Mammals is a very long one, but the most important orders in this connection are the Flesh-Eaters (Carnivora) and the Gnawers (Rodentia), and the purpose of the present section will be sufficiently attained by dealing with a few species belonging to these. It may be noted that we look to the colder parts of the world, especially Canada and Russia, for our chief supply, for the growth of a dense under-coat of fur is an adaptation to rigorous climatal conditions. And it is the pelts obtained in winter that are valuable. In 1902 Canada exported furs to the value of £98,000.

FUR-YIELDING FLESH-EATERS (CARNIVORA).—Some of the most important furs of commerce are derived from the members of the Weasel and Marten Family (Mustelidæ). Pre-eminent among these is the Russian Sable (*Mustela zibellina*), which formerly abounded throughout the forest regions of Siberia, but is now mostly to be found in the eastern part of that country, including Kamschatka, where the seaport of Petropavlosk is an important depôt for the pelts. A single skin may be worth as much as £30 in this country. The chief method of hunting is by means of dogs, which force the sables to take refuge in trees, from which they are shaken or knocked down into suitably disposed nets. The closely allied American Sable (*M. Americana*), largely trapped in Canada, is also of considerable importance.

The white skins (with black tails) known as "ermine", which custom leads us to associate with the "great ones of the earth", are no other than the winter coats of the Stoat (*Putorius erminea*), one of our native "vermin". It is widely distributed through the arctic and temperate regions of both Old and New Worlds, but only assumes full winter livery in the colder parts of its area of distribution.

The *Minks* or *Visons* are comparatively large aquatic animals of the weasel kind, with brown fur. The pelts of the American Mink (*Putorius vison*) are most esteemed, and are of importance

in the Canadian fur-trade. Those of the Russian Mink (*P. lutreola*) are less valuable.

Passing over Bears, Foxes, Leopards, &c., mention must be made of Sea-Otters and Fur-Seals, of which the latter in particular are of great economic importance.

The *Sea-Otter* (*Latax lutris*), native to the coastal waters of the North Pacific, has been so persistently hunted down that its numbers have rapidly diminished during the last twenty years, and it is probably doomed to speedy extinction. Spearing, clubbing,

Fig. 1221.—Northern Fur-Seals (*Otaria ursina*) on the Pribyloffs

and netting are the chief modes of capture. The fur of the adult is very dense, and of a beautiful dark colour. Owing to their rarity skins are now of great value, a single one being worth at least £100, or, in exceptional cases, double that amount or even still more.

Certain species of *Sea-Lions* or *Eared Seals* (Otaridæ) are the "fur seals" of commerce, which furnish the valuable skins with which most of us are familiar. Some of them are native to the Southern seas, but the most notable kind is the *Northern Fur-Seal* (*Otaria ursina*, figs. 1221 and 1222), or Sea-Bear of the Pacific. The Pribyloff Islands of the Behring Sea have long been famous as one of the most important centres of the industry to which this

THE SABLE (*Mustela zibellina*)

This small carnivore, a near relative of our native Pine Marten, is one of the most valuable of fur yielding animals. It formerly ranged across the northern parts of Asia, from the Urals to the Behring Sea, but has been so persistently hunted down that it is now chiefly found in the forests of eastern Siberia and Kamschatka, Petropavlovsk on the coast of the latter being the chief depôt for sable skins. It is only the thick winter fur that is valuable, and a good pelt may be worth as much as £30.

Sables were formerly caught for the most part by trapping, and sometimes guns were resorted to, though with great risk of injury to the skin. At the present time they are usually hunted down with dogs and forced to take refuge in trees, from which they are shaken or knocked down into suitably disposed nets.

THE RUSSIAN SABLE (MUSTELA ZIBELLINA), THE KING OF THE MARTENS

species gives rise. As elsewhere briefly described (vol. iii, p. 492), large numbers of the fur-seals repair to these islands during the summer for the purpose of bringing up their young. It is the young "bachelor" males, or "holluschickie", that are not strong enough to secure establishments, which are slaughtered for the sake of their skins. These are carefully driven to inland "killing grounds", knocked on the head, and flayed as quickly as possible. Very full details of the industry are given by H. W. Elliot in his well-known book *An Arctic Province*, from which the following extract is taken —"The common or popular notion in regard to seal-skins is, that they are worn by those animals just as they appear when offered for sale; that the fur-seal swims about, exposing the same soft coat with which our ladies of fashion so delight to cover their tender forms during inclement winter. This is a very great mistake, few skins are less attractive than a seal-skin is when it is taken from the creature. The fur is not visible, it is concealed entirely by a coat of stiff over-hair, dull, gray-brown, and grizzled. It takes three of them to make a lady's sack and boa; and in order that a reason for their costliness may be apparent, I take great pleasure in submitting a description of the tedious and skilful labour necessary to their dressing by the furriers ere they are fit for use. A leading manufacturer writing to me says: 'When the skins are received by us in the salt, we wash off the salt, placing them upon a beam somewhat like a tanner's beam, removing the fat from the flesh side with a beaming-knife, care being required that no cuts or uneven places are made in the pelt. The skins are next washed in water and placed upon the beam with the fur up, and the grease and water removed by the knife. The skins are then dried by moderate heat, being tacked out on frames to keep them smooth. After being fully dried, they are soaked in water and thoroughly cleansed with soap and water. In some cases they can be unhaired without this drying process and cleansed before drying. After the cleansing process they pass

Fig 1222 —Northern Fur Seals

to the picker, who dries the fur by stove-heat, the pelt being kept moist. When the fur is dry he places the skin on a beam, and while it is warm he removes the main coat of hair with a dull shoe-knife, grasping the hair with his thumb and knife, the thumb being protected by a rubber cob. The hair must be pulled out, not broken. After a portion is removed the skin must be again warmed at the stove, the pelt being kept moist. When the outer hairs have been mostly removed, he uses a beaming-knife to work out the fine hairs (which are shorter), and the remaining coarser hairs. It will be seen that great care must be used, as the skin is in that soft state that too much pressure of the knife would take the fur also; indeed, bare spots are made. Carelessly-cured skins are sometimes worthless on this account. The skins are next dried, afterwards dampened on the pelt side, and shaved to a fine, even surface. They are then stretched, worked, and dried, afterwards softened in a fulling-mill, or by treading them with the bare feet in a hogshead, one head being removed and the cask placed nearly upright, into which the workman gets with a few skins and some fine hardwood saw-dust, to absorb the grease while he dances upon them to break them into leather. If the skins have been shaved thin, as required when finished, any defective spots or holes must now be mended, the skin smoothed and pasted with paper on the pelt side, or two pasted together to protect the pelt in drying. The usual procêss in the United States is to leave the pelt sufficiently thick to protect them without pasting. In dyeing, the liquid dye is put on with a brush, carefully covering the points of the standing fur. After lying folded, with the points touching each other, for some time, the skins are hung up and dried. The dry dye is then removed, and so on, until the required shade is obtained. One or two of these coats of dye are put on much heavier and pressed down to the roots of the fur, making what is called the ground. From eight to twelve coats are required to produce a good colour. The skins are then washed clean, the fur dried, the pelt moist. They are shaved down to the required thickness, dried, working them some time while drying, then softened in a hogshead, and sometimes run in a revolving cylinder with fine saw-dust to clean them. The English process does not have the washing after dyeing.'"

Fur-Seals are also hunted in the open sea, at times when the herds are migrating. The United States endeavoured to put an

end to this "pelagic" sealing in the Behring Sea on the part of other nations, but the matter being submitted to arbitration, it was decided that, subject to certain restrictions, the practice should be allowed to continue. The yield of the fur-seal industry of British Columbia in 1900 was 35,523 skins (value $562,845), and in 1901 24,422 skins (value $366,330).

FUR-YIELDING GNAWERS (RODENTIA)—Beaver, Chinchilla, Musquash, Squirrel, and Rabbit are here of greatest importance.

Fig 1223—Musquash (*Fiber zibethicus*)

The Beaver (*Castor*).—The American Beaver (*Castor Canadensis*) is largely trapped in Canada for the sake of its fur, which is greatly esteemed, though no longer used in the manufacture of top-hats, silk having proved both cheaper and better for the purpose. The animal has been slaughtered in so wholesale a manner that beaver-fur is becoming increasingly rare and expensive.

The European Beaver (*C. fiber*), once abundant, is now too scarce to be of economic value. Regarding the value attached to the skins of those which existed in Wales down to 1188, Beddard (in *The Cambridge Natural History*), after stating that the species was extinct in England before the historic period, remarks: ". . . they were rare in the Principality for a hundred years or so before

the Norman Conquest. The king Hywel Dda, who died in 948 A.D., fixed the price of a Beaver skin at 120 pence, the skins of Stag, Wolf, and Fox being worth only 8 pence apiece."

The Musquash (*Fiber zibethicus*, fig. 1223).—This is a large North American vole, which is of considerable importance to the Canadian fur-trade, chiefly, it would seem, because it is made into imitation seal-skin.

The Chinchilla (*Chinchilla lanigera*).—The cold climate to which the soft gray fur of this pretty little rodent is an adaptation, is here a result not of latitude but of altitude. Chinchillas live in the high Andes of Peru and Bolivia, and are something like squirrels in appearance, except that the tail is far less bushy (see vol. i, p. 134).

The Common Squirrel (*Sciurus vulgaris*).—This species has a remarkably wide distribution, ranging from Ireland to Japan, and also being native to North Africa. It is the chief source of "squirrel" fur, which is of grey or drab colour, quite unlike the reddish-brown of our ordinary native specimens. The skins of commerce are, in fact, taken from individuals inhabiting the colder parts of Russia, the grey hue being, as in many other cases, an adaptation to the severe climate of winter.

The Rabbit (*Lepus cuniculus*).—Among the cheaper kinds of fur that of the rabbit is best known, and by means of dyeing and other processes it is worked up into passable imitations of more costly pelts.

SKINS AND DOWN OF WILD BIRDS (AVES)

Deferring for the present the question of the wild birds which are subjected to wholesale butchery on account of their beautiful plumage, mention may here be made of Grebes and Eider-Ducks.

Grebes (species of *Podicipes*).—These widely-distributed aquatic birds are distinguished by the density and beautiful silver-white colour of the plumage on the under side of the body. Muffs and other articles made of "grebe" are manufactured from the skin of this region, with the feathers attached as in nature.

Eider-Ducks (*Somateria*, fig. 1224).—Two species of these essentially Arctic birds are of commercial importance on account

of the valuable down developed on the nest as a climatal adaptation The Common Eider (*Somateria mollissima*), which has a wide range, and is included in the British avifauna, is carefully preserved in Iceland and Norway In Labrador and Greenland it is replaced by an allied species (*S Dresseri*)

The Scandinavian eider industry is based on the fact that the female bird lines and covers her nest with down plucked from her own breast (see p 60) The breeding-places are on low ground near the coast or upon rocky islets, and each "ederfold" (*i e* eider fold) is worked for profit by a special proprietor Both eggs and down are collected at regular intervals during the nesting season, but the amount obtainable from a particular nest

Fig 1224 —Eider Drake (*Somateria mollissima*)

is, of course limited, and care is taken to allow the despoiled mother birds to hatch out some at least of the final batch of eggs. The last lot of down is collected when the nests have been deserted for the season About three quarters of the Danish supply is derived from Greenland Newton (in *A Dictionary of Birds*) thus disposes of two popular errors regarding these birds The story of the drakes furnishing down after the duck's supply is exhausted is a fiction He never goes near the nest Equally fictitious is the often repeated statement that eider down is white Mouse colour would perhaps best describe its hue '

WILD ANIMALS YIELDING LEATHER, HORN, FAT, ETC

It has been considered desirable in this book to deal with domesticated animals in a special section, but the plan (like any other) has certain disadvantages, especially when treating of

economic products. Leather, horn, fat, &c. &c., are, of course, derived from both tame and wild animals, and this must be kept in mind here. The importance of leather and horn will be realized by reading the following extracts from Simmonds (in *Animal Products*):—"The leather manufacture is one of our most ancient and important industries. . . . The old adage that there is nothing like leather is certainly verified in the multifarious uses to which leather has been or is now put. We make coverings of it in articles of personal use, for a man may be clothed in leather garments from the head to the foot. In saddlery and harness its use is universal, and nothing can supplant it for durability. In articles for household or domestic use, we have leather hangings and coverings for furniture, buckets and bottles, cups and hose. . . . For travelling we have portmanteaus, valises, and hand-bags, pocket-books, purses, and cigar-cases. . . . We write on leather, and we cover our books with it, and it has even been used by photographers to take likenesses on. It is the packing and baling material in many countries from its cheapness and durability. Hammocks, boats, and even cannon have been made of it, whilst the leather apron is the most durable and serviceable protection for many an artisan. Leather shields were and are still in use in many countries. It serves for the grip-handle of swords, and for the sheaths of knives. We use leather in balls for cricket and football, and we cover musical instruments with it, as well as telescopes and many philosophical instruments, for protection. It is the most ancient, useful, and generally applied animal substance for an infinite variety of purposes. And, moreover, leather can be made of the skin or hide of almost every quadruped, and of many fishes, serpents, and reptiles. Human skin has even been tanned, but it is too thin for any serviceable use." In the following remarks about horn it will be remembered that the antlers of deer are of bony nature:—"The rights and privileges of the 'horn-workers' and 'horn-pressers' in former times occupied the prominent attention of the Legislature. But there is no fear in the present day 'of the trade being ruined, and the business lost to the nation', as was the cry when the statutes 6 Edward IV, c. 1, and 7 James I, c. 14 were passed, forbidding the sale of horns to foreigners, and prohibiting the export of our wrought horns. The invention of horn lanterns has been by some ascribed

to King Alfred, who is said to have first used them to preserve his candle time-measurers from the wind. . . . A lantern [was formerly] an indispensable family article; there was no going into the yard or out of the door on dark nights without one. A piece of horn was sometimes placed over the title of mediæval MSS. to preserve the letters from injury, while the transparent material allowed them to be read. The child's horn-book of later times had its leaves of alphabet and spelling covered entirely with thin sheets of this material. Although the principal manufacturing applications of horn are for combs, umbrella-tops, and knife-handles, yet there are other uses as extensive and varied as the descriptions of horn which come into the market, or bristle on the head of the animals characterized by these frontal appendages. Ox, buffalo, and deer horns are those mostly worked up, but the horns of the rhinoceros, ram, goat, and some other animals are also employed to a limited extent for different purposes. . . . While many of the former uses of horns for glazing purposes, for drinking-cups, for horn-books, and for the bugle of the bold forester have passed away, other and more elegant and varied applications have been found for this plastic and durable substance. Extensive as is the present use of horns, we believe that many further manufacturing purposes may be found for them, and that they will become even still more important in a commercial point of view. They receive a great variety of applications at the present day, owing to their toughness and elasticity, as well as their remarkable property of softening under heat, of welding, and of being moulded into various forms under pressure." It may be added that for many purposes both leather and horn are now replaced by cheap substitutes.

As most of the horns used on a large scale for manufacturing purposes are those of oxen, it will suffice to devote the rest of this sub-section to the consideration of certain wild animals captured chiefly for the sake of the leather and fat which they yield.

THE WALRUS (TRICHECHUS ROSMARUS).—This huge aquatic carnivore, which may attain the weight of 3300 lbs., is a purely Arctic form, and once abounded in the Behring Sea, the Gulf of St. Lawrence, and on the coasts of Newfoundland and Labrador. Like so many other wild animals, however, it has been so much

hunted down that the walrus industry is a declining one. Rifle, lance, and harpoon are all employed in its destruction. The economic products are skin, fat, and ivory. The skin is very thick and tough, but tanning reduces its value. It is employed for some of the coarser purposes to which leather is put, and in former times was largely used in North Europe for making ropes and cables, to which end strips of it were plaited together. The fat or blubber, though of good quality, is yielded in relatively small quantities. The ivory making up the large tusks is inferior to that of the elephant.

SEALS (PHOCIDÆ).—These are often confounded with the Fur-Seals (Otaridæ) and their allies, from which, however, they are distinguished by their more complete adaptation to an aquatic life, as seen more particularly in the complete absence of an external ear, and the backwardly-directed hind-flippers, which are bound together by a fold of skin (see vol. iii, p. 78).

Seals are hunted for the sake of their blubber, which makes excellent oil for lighting and lubricating purposes, and also on account of the value of their skins, which are dressed as one of the coarser furs; while they yield leather that, especially when enamelled, finds increasing favour. The animals are killed by clubs, harpoons, or rifles, according to circumstances. By far the most important species for the sealing industry is the Harp or Greenland Seal (*Phoca Grœnlandica*, fig. 1225), the former name of which has reference to the presence of a curved black mark on the back of the male. Next to this species in importance, and like it native to the Arctic Ocean, is the curious Hooded or Bladder-Nosed Seal (*Cystophora cristata*), so named from a dilatable swelling on the nose of the male. The most noted sealing centres are the coasts of, and the parts of the sea adjacent to West Greenland, Newfoundland, Jan Mayen Island, and North Russia (including the White Sea and the vicinity of Nova Zembla). From the British stand-point it is most interesting to notice that sealing is one of the chief industries of Newfoundland, its products in 1902 reaching the value of £166,747. The young are born on ice-floes, the "whelping ice", off the coast of Labrador, during January and February, and do not take to the water for about three months. The cold Labrador current, which sets southward along the American coast, brings the "whelping ice" to the latitude of Newfoundland by about mid-March,

and the well-equipped steam-sealers of St John's begin their annual sealing-trip at the commencement of that month, timing their journey to reach the floes before the "whelps" are old enough to leave the ice.

Lake Baikal and the Caspian Sea were once connected with the Arctic Ocean, one proof of which is found in the fact that each is inhabited by a special kind of seal (*Phoca Sibirica* and *P. Caspica*), both of which are largely captured by means of

Fig 1225 —Harp or Greenland Seal (*Phoca Grœnlandica*)

strong wide-meshed nets, worked on the same principle as the "drift-nets" used for catching herring and mackerel The Caspian sealers let down their nets from boats, those of Lake Baikal take advantage of the holes in the ice, to which the seals come up in order to breathe.

THE DUGONG (HALICORE DUGONG)—This member of the order of Sea-Cows (Sirenia), which ranges from Ceylon to East Australia, is, when adult, about the size of an ox, and is captured for the sake of its flesh, fat, and hide. Its pursuit is one of the Queensland industries, and harpooning is the method adopted. Semon (in *In the Australian Bush*) says of it —

"The whites capture dugong principally for their fat, which is said to possess therapeutic qualities. It is considered an excellent remedy for consumption, but, happily for the dugongs, this seems to be a mere superstition. I have not tasted their meat myself, though some whites are very fond of it, and compare it to veal. Others, however, describe its taste as disagreeable and insipid. The aborigines of Torres Straits consider it a great delicacy." The hide is thick and tough, rendering it suitable for machine-straps.

WHALES, &c. (CETACEA).—Whales and their kind have been systematically hunted down from very remote times, chiefly for the sake of their fat or blubber, but some species also for their baleen or "whale-bone", and others on account of the value of their skins. As elsewhere stated (p. 209), the flesh of cetaceans is regarded as a great luxury by the Esquimaux and many other primitive peoples. A distinction is drawn between the Toothed Whales and the Toothless Whales, in which transverse plates of baleen, with fringed edges, hang down from the roof of the mouth (fig. 1226), serving as a sort of strainer by which water is removed from the plankton used as food.

b

Fig 1226.—Baleen a, Three plates in section. b, a pair of plates. Greatly reduced.

Toothless Whales (*Mystacoceti*).—The most important member of this group is the Greenland or Northern "Right" Whale (*Balæna mysticetus*), a purely Arctic species. The British whaling industry, of which the chief ports engaged are Peterhead and Dundee, is chiefly concerned with the capture of this animal, but unfortunately has greatly declined of late years. To Newfoundland the pursuit of whales is a matter of much greater relative importance.

The old method of capture was from open boats, by means of harpoons thrown by hand, lances being afterwards used to despatch the wounded animals. The harpoon-gun afforded an improvement upon this, while a modern steam-whaler can dispense with the use of open boats, and discharge harpoons (sometimes loaded with explosives) from a platform in the bows.

Adult Greenland whales now attain a length of 50 or 60 feet, but much larger specimens were often captured in the palmy days of the whaling industry. The average product from a single animal is said to be about 15 tons of oil and 15 cwts. of whalebone. The former, like that of seals, is valuable as a lubricant and for other technical purposes, but the discovery of petroleum has greatly lessened the value of this and other animal fats as a source of artificial heat and light. Whalebone is becoming increasingly expensive in proportion to the diminishing supplies, and is still in great demand for a number of purposes, owing to its toughness, durability, and elasticity. It is now largely replaced by steel, as, *e.g.*, for umbrella-frames and corsets.

The Southern "Right" Whale (*B. australis*), which closely resembles the Greenland form, though its baleen is not of such good quality, has a very wide area of distribution, but is absent from the Arctic Ocean. The chief interest attaching to it is that at one time it was common in the Bay of Biscay, where it formed the object of an important industry, especially to the Basques of North Spain. Some points relating to this are thus summarized by Beddard (in *The Cambridge Natural History*):—"Among the small towns which fringe the bay it is very common to find the whale incorporated in the armorial bearings. 'Over the portal of the first old house in the steep street of Guetaria', writes Sir Clements Markham (*P. Z. S.*, 1881), 'there is a shield of arms consisting of whales amid waves of the sea. At Motrico the town arms consist of a whale in the sea harpooned, and with a boat with men holding the line.' Plenty of other such examples testify to the prevalence of the whaling industry on these adjoining coasts of Spain and France. It appears that though the fishery began much earlier—even in the ninth century—the first actual document relating to it dates from the year 1150. It is in the shape of privileges granted by Sancho the Wise to the city of San Sebastian. The trade was still very flourishing in the sixteenth century. Rondeletius the naturalist described Bayonne as the centre of the trade, and tells us that the flesh, especially of the tongue, was exposed for sale as food in the markets. M. Fischer (*Actes Linn. Soc. Bordeaux*, 1881), who, as well as Sir Clements Markham, has given an important account of the whaling industry on the Basque shores, quotes an account of the methods pursued in the sixteenth century. It was at Biarritz

—or as Ambroise Pare, from whom Fischer quotes, spelt it, Biaris—that the main fisheries were undertaken. . . . The inhabitants set upon a hill a tower from which they could see 'the balaines which pass, and perceiving them coming partly by the loud noise they make, and partly by the water which they throw out by a conduit which they possess in the middle of the forehead.' Several boats then set out in pursuit, some of which were reserved for men whose sole duty it was to pick out of the water their comrades who had overbalanced themselves in their excitement. The harpoons bore a mark by which their respective owners could recognize them, and the carcass of the animal was shared in accordance with the numbers and owners of the harpoons found sticking in the dead body of the whale. At this period the fishery was at its height, but it continued to be an occupation along those shores until the beginning of the eighteenth century, after which it gradually declined. The fishery of whales began to be carried farther afield than the shore, and for a long time the Basques furnished expert harpooners to whaling vessels proceeding to the Arctic seas.'

Toothed Whales (Odontoceti).—The largest of these is the Cachalot or Sperm Whale (*Physeter macrocephalus*, fig. 1227), which has been credited with reaching a length of over 80 feet, though this is probably an exaggeration. It ranges throughout the warmer seas of the world. The great head possesses a squarish snout that projects in front of the mouth, which is consequently placed on the under side of the body, obliging the Cachalot, it is said, to turn over like a shark when it wishes to bite. Many stories are current regarding the fierceness of this animal, and no doubt many whale-boats have been crushed in its formidable jaws, but that whaling and other vessels have at times been reported "missing" as a result of the attacks of Cachalots, as has been suggested, would appear to be more problematical. Like other cetaceans, this whale has a thick coat of blubber under the skin, and the front part of the skull is modified into a curious basin-shaped receptacle, which is full of the liquid fat known as spermaceti. As much as forty-five barrels of this have been taken from a single individual. Mixed with a small percentage of bees'-wax it was formerly much used in manufacturing candles of the better sort.

The White Whale or Beluga (*Delphinapterus leucas*) is an

Arctic species related to the Dolphins and Porpoises. The average length of adults is about 10 feet. but this may be considerably exceeded. It is chiefly hunted on the north of Russia and north-east of Canada, and is one of those cetaceans which ascend rivers. The blubber is of good quality, and the skin is made into the "porpoise leather" of commerce, which is of con-

Fig. 1227.—Cachalot or Sperm Whale (*Physeter macrocephalus*)

siderable value for the manufacture of shooting-boots and some other articles.

Reptiles (Reptilia).—It need only be said here that ornamental leather is made from the skins of Crocodiles and various Lizards, while "tortoise-shell" is obtained from certain Turtles. Of the last something will be said in a succeeding section.

Fishes (Pisces).—The skins of various members of this group are of economic value. Those of certain sharks and dog-fishes, for instance, are the source of "shagreen", used to some extent as ornamental leather, but chiefly for polishing wood. Their value for the latter purpose depends upon the fact that they are full of little hard-pointed scales, covered with enamel. The skins of some of the ordinary bony fishes (Teleostei) are employed for

clarifying beer, while in Eastern countries, such as India and China, they are converted into fish-glue, which is a very powerful adhesive.

Other fishes serve as a source of oil for technical purposes, as, *e.g.*, the Menhaden or Pogy (*Clupea menhaden*), a member of the herring family. This species is largely captured on the eastern coasts of the United States for this particular purpose. The livers of sharks and dog-fishes are also of considerable value as a source of oil.

INSECTS (INSECTA).—One would scarcely expect this group to be included under the present heading, but it appears that in Algeria locusts are utilized in the preparation of a kind of oil.

MEDICINAL AND MISCELLANEOUS ECONOMIC PRODUCTS

ANIMALS AND ANIMAL PRODUCTS AS MEDICINAL AGENTS.—In former days large use was made of animals in medicine, the prescriptions being usually fanciful and often revolting. To consider these ancient practices at length would be here superfluous, and the subject will be sufficiently illustrated by the following quotation from Hulme's *Natural History Lore and Legend*, a book in which much curious matter is brought together:—"Cogan in his *Haven of Health* declares 'thus much will I say as to the commendation of the hare, and of the defense of hunters' toyle, that no beast, be it never so great, is profitable to so many and so diverse uses in Physicke as the hare', and he then proceeds to give numerous prescriptions in which it is the principal feature. 'The knee-bone of an Hare taken out alive and worne abute the necke is excellent against Convulsion fitts', we are told, and perhaps it may be so, but the point that more especially strikes us, and it impresses one over and over again in these mediæval recipes, is the cold-blooded cruelty and indifference to animal suffering that is shown in so many of them. Fried mice were considered a specific in small-pox, but it was necessary that they should be fried alive, while for cataract a fox should be captured, his tongue cut out, and the animal released; the member thus barbarously procured was placed in a bag of red cloth and hung round the man's neck. For erysipelas a favourite old remedy was to cut off one-half of the ear of a cat and let the blood drop on the part affected, while for fits one popular recipe was to take a mole

alive, cut the tip of his nose off, and let nine drops of the blood fall on to a drop of sugar: the swallowing of this was held to be a certain cure."

"The shrew-mouse, one of the most inoffensive of creatures, was by our ancestors held to be of terribly poisonous nature. Its bite was thought to be most venomous, and even contact with it in any way was accounted extremely dangerous. Cattle and horses seized with any malady that appeared to cause any numbness of the legs were at once reputed shrew-struck. 'It is a ravening beast,' quoth Topsell, 'feigning itself gentle and tame, but being touched it biteth deep and poysoneth deadly. It beareth a cruel minde, desiring to hunt anything, neither is there any creature that it loveth.' On whatever limb it crept was 'cruel anguish', often ending in paralysis. These calumnies have prevailed in many countries and for many ages, the Romans being as firmly convinced of the deadly nature of the shrew-mouse as any British rustic of a century ago. . . . Happily there was a certain antidote against the evil wrought by this malevolent beast. A large ash-tree being chosen, a deep hole was made in its trunk, and after certain incantations were made a shrew-mouse was thrust alive into the opening, and the hole securely plugged. 'A shrew-ash', says Gilbert White in his *Natural History of Selborne*, 'is an ash whose twigs or branches, when gently applied to the limbs of cattle, will immediately relieve the pain which a beast suffers from the running of a shrew-mouse over the part affected. Against this accident, to which they were continually liable, our provident forefathers always kept a shrew-ash at hand, which when once medicated would maintain its virtue for ever.' One of these shrew-ashes, now but a fragment of what was evidently once a massive stately tree, may still be seen (1895) near the Sheen Gate in Richmond Park, and there are those still living who can remember cattle and horses being brought to it for its healing virtues."

"To cure a stye our forefathers had great faith in rubbing it with hairs from a cat's tail, two essential points being that the cat should be a black one, and that the operation should take place on the first night of the new moon; but to cure warts the hairs must be taken from the tail of a tortoise-shell cat, and even then the remedy is only efficacious during the month of May."

"Toads were in great repute in sickness. 'In time of com-

mon contagion,' writes Sir Kenelm Digby in 1660, 'men used to carry about with them the powder of a toad, and sometimes a living toad or spider shut up in a box, which draws the contagious air which otherwise would infect the party'; and many other illustrations of their employment as preventive or remedies might be given. The spider and the toad seem to have been each regarded as most venomous creatures, and in many of the old remedies one or other of them at will are recommended, either alternative being regarded as equally efficacious; thus for whooping-cough, if one cannot find a toad to thrust up the chimney, two spiders in a walnut-shell will serve equally well."

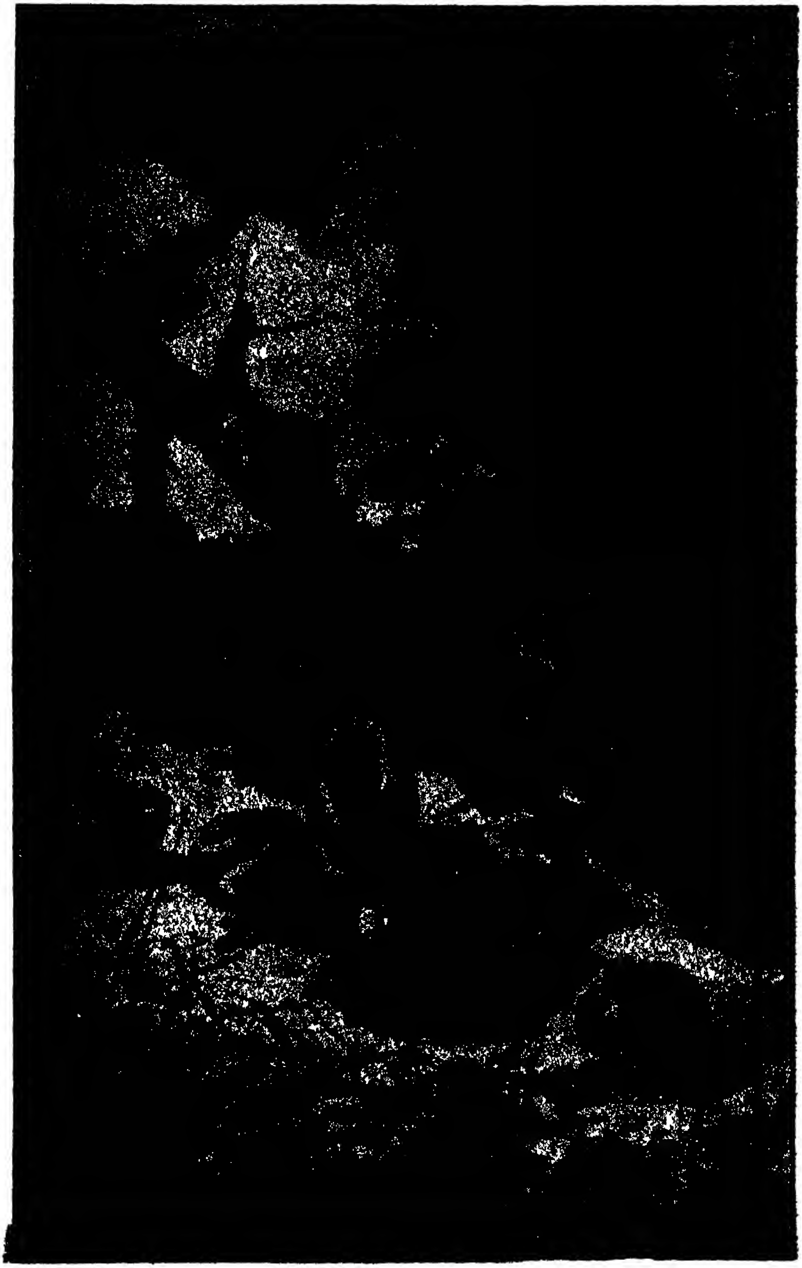
The physicians of former times were particularly fond of administering all sorts of animal extracts, some of them noisome enough, and it is somewhat curious that of recent times large use has been made of certain such extracts with beneficial result, though it need hardly be said that our modern methods of preparation are not on the old lines. Pepsin, for instance, a well-known aid to gastric digestion, is prepared from the lining of the pig's stomach, while pancreatin, which facilitates intestinal digestion, is obtained from the pancreas of domestic animals. Disease of the thyroid "gland" in the throat leads to serious mal-nutrition, or even to cretinism, palliation if not cure of which can be effected either by grafting a healthy piece of thyroid from an animal into the patient, or by administering thyroid extract. Several other preparations of the kind are also in use. Certain specific germ-diseases can also be prevented or combated by animal preparations, the most familiar instance being that of vaccination as a safeguard against small-pox. Diphtheria is now often cured by an extract (antitoxin) derived from horse's blood. Different principles are involved in the uses of the extracts, &c., mentioned, but details would here be out of place.

Various kinds of animal fat are used in pharmacy in the preparation of ointments, &c. They include mutton suet, hogs' lard, spermaceti, and lanoline, the last being the natural grease of wool. Gelatine is employed for making "gelatine lozenges" and various jujubes, also as the adhesive medium for "court plaster". It is obtained from bones, hides, horns, and hoofs by steaming. Isinglass (see p. 278) is a superior kind of gelatine.

It should not be forgotten that the careful study of the anatomy and physiology of lower animals has played a leading

VARIETIES OF THE FIELD-SNAIL (*Helix hortensis*)

Variation is one of the fundamental phenomena upon which the Evolution Theory is based. No two individuals of the same species are ever precisely alike, a fact familiarly illustrated by the dissimilarity which often exists between children of the same parents. It appears that all parts of the body are liable to variation, which may be of very marked kind and is no doubt, at least in part, due to the action of surroundings. A typical case, selected for this plate because it appeals to the eye, is that of the Field-Snail (*Helix hortensis*), of which some 90 races or varieties have been described. In some of these the shell is "self coloured", yellow or pinkish brown being common tints. In other cases there are in addition dark bands, the number of which is distinctive of the race, while the ground colour has also to be considered. Enough varieties have been introduced into the plate to illustrate the principle.



VARIETIES OF THE FIELD-SNAIL (HELIX HORTENSIS)

part in the evolution of modern medicine. Without skilled researches on such animals it would never have been possible for operative surgery to reach its present high pitch of perfection. The prevention and cure of disease, other than by surgical methods, have also benefited greatly in the past by such investigations, and seem likely to benefit to a much larger extent in the immediate future.

Medicinal Value of Fish-Oil.—It need only be said here that the preparation of cod-liver oil, of which the Cod-Fish (*Gadus morrhua*) is the recognized source, is a by no means unimportant industry.

Medical Uses of Insects.—The Oil-Beetles (*Meloidæ* or *Cantharidæ*) are so called because they abound in an irritant sort of oil, which no doubt protects them to some extent from the attacks of insectivorous animals. Some of them are used to make preparations for blistering the skin, and of these "blister-beetles" the most notable are the "Spanish flies" (*Cantharides*), belonging to South and Central Europe. For commercial purposes a bright-green species (*Lytta vesicatoria*, fig. 1228), collected in Hungary, is most important. Various officinal extracts and plasters are prepared from the dried bodies of these insects.

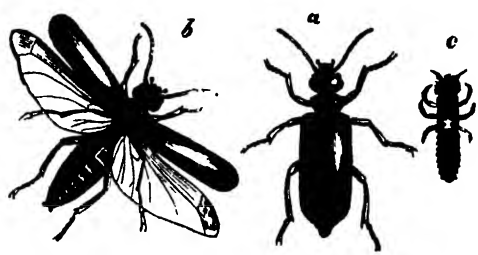


Fig. 1228.—Spanish Fly or Blister Beetle (*Lytta vesicatoria*) *a* and *b*, Adults. *c*, larva

Although Cochineal, another insect product (see p. 260), appears to have no value as a drug, it is largely used to give liquid medicines an attractive appearance.

Medicinal Use of Leeches (*Discophora*).—Two kinds of Leech are used for blood-letting, the commoner being the Medicinal Leech (*Hirudo medicinalis*), which is mostly collected in Spain, France, and Italy. The Green Leech (*H. officinalis*) of Hungary answers the same purpose. In these days the extent to which these creatures are employed is comparatively small, but in the Middle Ages, when blood-letting was esteemed a sovereign cure for every ailment, the physician took his name from this favourite remedy, and was familiarly known as a "leech".

Miscellaneous Animal Products.—It will be convenient to consider here a few odds and ends, which are difficult to place under other headings.

Miscellaneous Products of Molluscs (*Mollusca*).—The internal shell of the Cuttle-fish (*Sepia officinalis*, fig. 1229), under the name of "cuttle-bone", is ground up to form an ingredient of various tooth-powders. Before the invention of blotting-paper it was largely used (as also was fine sand) to sprinkle upon wet writing. It was known as "pounce", and a "pounce-box", with a perforated top, was part of the regular equipment of an old-fashioned ink-stand or standish.

Fig. 1229.—A Cuttle-bone

Cooke (in *The Cambridge Natural History*) makes the following interesting remarks about the miscellaneous uses of shells:—"The employment of shells as a medium of exchange was exceedingly common amongst uncivilized tribes in all parts of the world, and has by no means yet become obsolete. One of the commonest species thus employed is the 'money cowry' (*Cypræa moneta*, L., fig. 1230), which stands almost alone in being used entire, while nearly all the other forms of shell money are made out of portions of shells, thus requiring a certain amount of labour in the process of formation. . . . In British India about 4000 are said to have passed for a shilling, but the value appears to differ according to their condition, poor specimens being comparatively worthless. According to Reeve a gentleman residing at Cuttack is said to have paid for the erection of his bungalow entirely in cowries. The building cost him 4000 Rs. sicca (about £400), and as 64 cowries = 1 pice, and 64 pice = 1 rupee sicca, he paid over

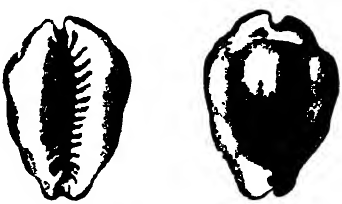


Fig. 1230.—Money Cowry (*Cypræa moneta*)

16,000,000 cowries in all. Cowries are imported to England from India and other places for the purpose of exportation to West Africa, to be exchanged for native products. The trade, however, appears to be greatly on the decrease. At the port of Lagos, in 1870, 50,000 cwts. of cowries were imported. A banded form of *Nerita polita* was used as money in certain parts of the South Pacific. The sandal-wood imported into the China market is largely obtained from the New Hebrides, being purchased of the natives in exchange for *Ovulum angulosum*, which they especially esteem as an ornament. Sometimes, as in the Duke of York group, the use of shell money is specially restricted to certain kinds of purchase, being employed there only in the buying of swine. Among the tribes of the north-west coasts of America, the common *Dentalium indianorum* [a tusk-shell] used to form the standard of value, until it was superseded, under the auspices of the Hudson's Bay Company, by blankets. A slave was valued at a fathom of from twenty-five to forty of these shells, strung lengthwise. Inferior or broken specimens were strung together in a similar way, but were less highly esteemed; they corresponded more to our silver and copper coins, while the strings of the best shells represented gold The *wampum* (fig. 1231) of the eastern coast of North America differed from all these forms of shell money, in that it required a laborious process for its manufacture. Wampum consisted of strings of cylindrical beads, each about a quarter of an inch in length and half that breadth. The beads were of two colours, white and purple, the latter being the more valuable. Both were formed from the common clam (*Venus mercenaria*), the valves of which are often stained with purple at the lower margins, while the rest of the shell is white. Cut small, ground down, and pierced, these shells were converted into money, which appears to have been current along the whole seaboard of North America from Maine to Florida, and on the Gulf Coast as far as Central America, as well as among the

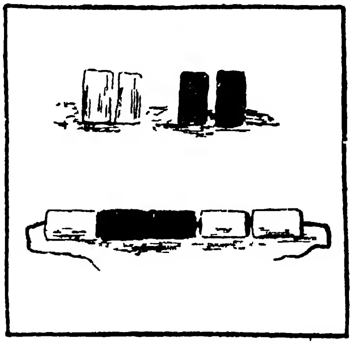


Fig 1231 — Indian Wampum Reduced

inland tribes east of the Mississippi. Another kind of wampum was made from the shells of *Busycon carica* and *B. perversum*. By staining the wampum with various colours, and disposing these colours in belts in various forms of arrangement, the Indians were able to preserve records, send messages, and keep account of any kind of event, treaty, or transaction. Another common form of money in California was *Olivella biplicata*, strung together by rubbing down the apex. Button-shaped discs cut from *Saxidomus arata* and *Pachydesma crassatelloides*, as well as oblong pieces of *Haliotis*, were employed for the same purpose, when strung together in lengths of several yards."

Shells are put to various uses in the islands of the Pacific, as, *e.g.*, the making of fish-hooks, spoons, knives, and axe-heads. The ingenious Chinese convert the thin translucent shell of a flat bivalve (*Placuna placenta*) into window-panes, grind up cockle-shells for lime, or, by mixing the powder with oil, make a sort of putty.

Speaking of the West of Scotland, Anderson Smith (in *Benderloch*) thus describes an old-time practice:—"There is a curious old custom that used formerly to be in use in this locality, and no doubt was generally employed along the seaboard, as the most simple and ready means of arrangement of bargains by a non-writing population. That was, when a bargain was made, each party to the transaction got one half of a bivalve shell—such as a mussel, cockle, or oyster—and when the bargain was implemented, the half that fitted exactly was delivered up as a receipt. Thus a man who had a box full of unfitted shells might be either a creditor or a debtor; but the box filled with fitted shells represented receipted accounts. Those who know the difficulty of fitting the valves of some classes of bivalves will readily acknowledge the value of this arrangement."

Sponges (*Porifera*).—The horny skeletons of certain sponges have been used for toilet and other purposes since the times of the ancient Greeks. The best kind of Bath Sponge (*Euspongia officinalis*), known to commerce as "Turkey Sponge", comes from the Mediterranean and Red Sea, as well as the less esteemed Zimocca Sponge (*Euspongia zimocca*) and Horse Sponge (*Hippospongia equina*). Other kinds, both fine and coarse, are imported from the Bahamas, and sponges of commercial value are to be found off Australia and some of the South Sea Islands.

Three methods of sponge-fishing are practised in the Mediterranean, according to the depth of water. Where this is very shallow a five-pronged fork is employed, beyond the range of which (up to about 30 fathoms) diving is resorted to, while specimens growing in comparatively deep water (up to 200 fathoms) are dredged. The yield of the Italian sponge-fisheries for 1902 was worth £24,720.

WILD ANIMALS BENEFICIAL TO MAN ON ACCOUNT OF THEIR HABITS

From the economic stand-point many wild forms are of very considerable benefit to man, because they prey upon other creatures which are injurious to himself, his stock, and his crops. To some such animals we should extend the "protection" which they deserve at our hands, while for others equally beneficial (*e.g.* certain insects) we can do nothing in that direction. And it should be remembered that without very full knowledge it is very risky either to mercilessly persecute native forms, or to introduce species from other countries. The result of the ruthless slaughter of bats in a particular locality has been elsewhere mentioned (see vol. ii, p. 346), while the introduction of rabbits into Australia has led to unexpected and undesirable consequences.

Certain other wild species deserve the name of "beneficials" because they promote the health of mankind, or unconsciously assist in the work of agriculture, &c.

It will sufficiently serve the purposes of this work if the general nature of our indebtedness to certain groups of animals is indicated in a few paragraphs. For this and the other aspects of applied natural history readers who may be interested are specially recommended to consult Theobald's *First Report on Economic Zoology* (1902), one of the publications issued under the auspices of the British Museum (Natural History). This is rendered particularly valuable by the Introduction ("A Classification of Animals from the point of view of Economic Zoology") written by Ray Lankester. The word "beneficials" is applied by him in a somewhat narrower sense than it is here.

BENEFICIAL MAMMALS (MAMMALIA).—The destructiveness of Foxes, Weasels, Stoats, and the like, is so obvious, that the idea of their being "beneficials" would be scouted by many, though

they probably do more good than harm. The Fox, for instance, in spite of his ravages on poultry, destroys large numbers of field-voles and field-mice, together with noxious insects, such as cockchafers. And, of the Weasel (fig. 1232), Ritzema Bos says (in *Agricultural Zoology*):—" The weasel does some damage in fowl-houses and dove-cots, and is also destructive to game. This, however, does not outweigh its very great use, since it is above all an untiring vole-catcher. When in any region the field-voles have multiplied excessively, an immigration of weasels takes place from surrounding parts. In years when there is a plague of voles the usual breeding-time in spring is followed by another later on. A very large number of weasels may be found in a vole-infected district, and they thin out the mischievous rodents in a surprising manner. Nor are the weasels less useful in winter than in summer. They even follow under the snow the voles which winter in the country, and the slaughter effected at this period must exert a great influence on the following season, when these animals recommence their injurious work." The feelings of poultry-keepers and game-keepers are readily intelligible, but without full knowledge it is unwise to stigmatize as " vermin " apparently undesirable animals. Foxes only escape the libel for sporting reasons.

Fig. 1232.—Weasels (*Putorius vulgaris*)

The Insect-eating Mammals (Insectivora), such as Mole, Hedgehog, and Shrews, destroy enormous numbers of noxious insects and insect-larvæ, and are beneficials of the first rank. The mole is also of use in mixing and draining the soil. The vast majority of Bats (Chiroptera) feed on insects, and do much to keep down the numbers of the innumerable species which are injurious to stock and cultivated plants, as well as to forest-trees.

In the hotter parts of the globe some Mammals do useful work as scavengers, *e.g.* Hyænas (see vol. ii, p. 14). Rats and the like also act as sanitary agents.

Fig. 1233.—Barn Owl (*Strix flammea*) and Nest

Beneficial Birds (Aves). — By destroying field-voles, &c., and small birds of injurious character, many of the smaller birds of prey, such as Kestrels, Buzzards, and Merlins, do much good, though it must be confessed that there is another side to the matter. Aflalo says of the Kestrel (in *Natural History of the British Isles*):—"Its food consists almost entirely of mice, so that its persecution is wanton folly". Even should it prove requisite to classify any of our native species, unfortunately now existing in greatly diminished numbers, as "vermin", they ought to be destroyed in a merciful way. Some of the steel traps used for slaughtering these and other wild animals (such as rabbits) are a disgrace to civilization, and only fit for the days of rack and thumb-screw.

Owls are more useful, but even more disliked than the diurnal birds of prey, partly as a result of the superstitions associated with them. Aflalo makes the following apposite remarks in this regard about the Barn Owl (*Strix flammea*, fig. 1233).—"Its disappearance from neighbourhoods where it once was plentiful is

doubtless due to the short-sighted policy of persecution meted out to the unoffending bird by gamekeepers. As rats, shrews, and voles are among its favourite articles of food, a few of these voracious birds on an estate should be worth a ton of poison. . . . The way in which gardener, farmer, and game-preserver unite in persecuting this owl has been mentioned, and it is to be doubted whether they would achieve a far different result were they actually to breed and turn down rats and voles, of which this bird must annually destroy hundreds of bushels."

A great many birds render us invaluable service by destroying vast numbers of injurious insects and insect-larvæ. The Cuckoo (*Cuculus canorus*), for example, is a great protector of fruit-culture and forestry, for it greedily devours certain hairy kinds of caterpillar, which most other birds refuse to touch. Among other benefactors may be particularly mentioned—Swifts, Swallows, Martins, and Tit-Mice. In Germany various useful species are provided with suitable nesting-boxes and wintering-boxes, the size of the opening being adjusted to the particular kind of bird.

The African Secretary Bird (*Serpentarius secretarius*) is a notable destroyer of poisonous snakes, and is domesticated by the farmers of South Africa for the sake of its services in this direction.

There are also scavenging birds, such as Vultures, which in hot countries discharge a most useful office.

Beneficial Reptiles (Reptilia).—Lizards are certainly to be regarded as beneficials, for they feed largely upon injurious insects and the like. Many Snakes are also useful, and some of them render conspicuous service by preying upon small rodents. Some species may even be domesticated on this account, as, *e.g.*, the Corn Snake (*Coluber guttatus*) in North America, and the Rat Snake (*Zamenis mucosus*) in India.

Beneficial Amphibians (Amphibia).—All the members of the class are beneficial, inasmuch as they live upon insects, snails, slugs, and other destructive creatures. Ritzema Bos states that . . . . "in the research garden attached to the Rouen entomological laboratory the snails were entirely exterminated in 1891, as a result of introducing a hundred toads and ninety frogs". The Toad in particular is one of the most useful animals that can be put into a garden, effectually protecting

strawberries from the ravages of slugs and performing other valuable offices of like nature.

BENEFICIAL FISHES (PISCES).—Much of the scavenging work in the sea and fresh water is efficiently discharged by members of this class. Among freshwater fishes Carp are particularly valuable in maintaining the purity of our drinking supply, keeping it free from insects, insect larvæ, and decaying matter. They are not infrequently kept in reservoirs on this account. And since the larvæ of such notorious pests as gnats, mosquitoes, and sand-midges are all aquatic, we are largely saved from annoyance and even from disease by the good offices of these and various other freshwater fishes.

BENEFICIAL INSECTS (INSECTA).—There are quite a large number of insects which either when adult or in the larval state, or it may be throughout life, are the natural enemies of many notorious insect pests. Sufficient examples have already been given in vol. ii, chap. ix, vol. iii, pp. 391–393, and in pp. 194, 195 of the present volume.

Carrion is also largely destroyed by insect-larvæ, such as the grubs of Burying-Beetles and the maggots of various Flies. Nor must we forget the large part which insects take in the fertilization of plants (see p. 83), including many which are of great importance to mankind.

BENEFICIAL SPIDER-LIKE ANIMALS (ARACHNIDA).—Of the members of this group it need only be said that Spiders, in particular, largely assist in keeping the numbers of insects within due limits.

BENEFICIAL MYRIAPODS (MYRIAPODA).—The numerous kinds of Centipede undoubtedly destroy large numbers of noxious ground-insects, and have therefore a claim to be included among beneficial animals.

BENEFICIAL CRUSTACEANS (CRUSTACEA).—A large amount of scavenging work is carried on by the members of this class, and, so far as the sea is concerned, Crabs are particularly notable in this respect.

BENEFICIAL ANNELIDS (ANNELIDA).—Earth-Worms render considerable service to agriculture (see vol. ii, p. 258) in more than one way. They reduce large quantities of soil to a finely-divided state, making it into a suitable seed-bed, bring earth to the surface as a sort of natural "top-dressing", and it may be added that their

burrows in the ground help on the work of drainage and aeration. In short, the habits of these animals benefit the land in much the same way as the operations of ploughing, harrowing, and the like.

Beneficial Parasitic Worms.—At first sight one is rather apt to imagine that the members of the several groups of these not altogether pleasing creatures do nothing but harm. This is not, however, strictly true, for many of them pay special attention to noxious animals, and assist considerably in keeping down their numbers.

CHAPTER LXX

ANIMAL FOES—THE PERSONAL ENEMIES OF MAN

Personal Enemies among Mammals (Mammalia).—We are not justified in calling the fiercer and larger Mammals or other animals our enemies, simply because they defend themselves when attacked, and in most cases man will probably be found to have been the first aggressor. And even when that is not the case, at least when carnivorous forms are in question, casualties are usually the outcome of the Law of Hunger, or it may be parental solicitude.

Partly owing to its comparatively straightforward habits, the Lion (*Felis leo*), when left alone, does not attack human beings to the extent that might be supposed, unless pressed by hunger. Speaking of North-East Africa, Sir Samuel Baker says (in *Wild Beasts and their Ways*):—"In the locality which I have mentioned, the lions, although numerous, were never regarded as dangerous unless attacked; there was an abundance of game, therefore the carnivora were plentifully supplied, and a large area of country being entirely uninhabited, the lions were unaccustomed to the sight of human beings, and held them in respect. During the night we took the precaution to light extensive bonfires within our camp, which was well protected by a circular fence of impenetrable thorns, but we were never threatened by wild animals except on one occasion."

Where the country is thickly populated it is only to be expected that individual animals may at times acquire bad habits, or, as Vogt puts it (in *Mammalia*):—"Old experienced lions who know how little danger they are exposed to in breaking in upon the villages of the badly-armed negroes will, it appears, hanker after human flesh".

The stealthy cat-like habits of the Tiger (*Felix tigris*, fig. 1234) render it a good deal more dangerous to man than its

nobler cousin. But even the "man-eaters", which at one time undoubtedly accounted for a considerable number of the Indian natives, must have been but a small percentage of the tigers actually in existence. Of these once-dreaded marauders G. P. Sanderson gives the following graphic account (in *Thirteen Years among the Wild Beasts of India*):—"This truly terrible scourge to the timid and unarmed inhabitants of an Indian village is now happily becoming very rare; man-eaters of a bad type are seldom

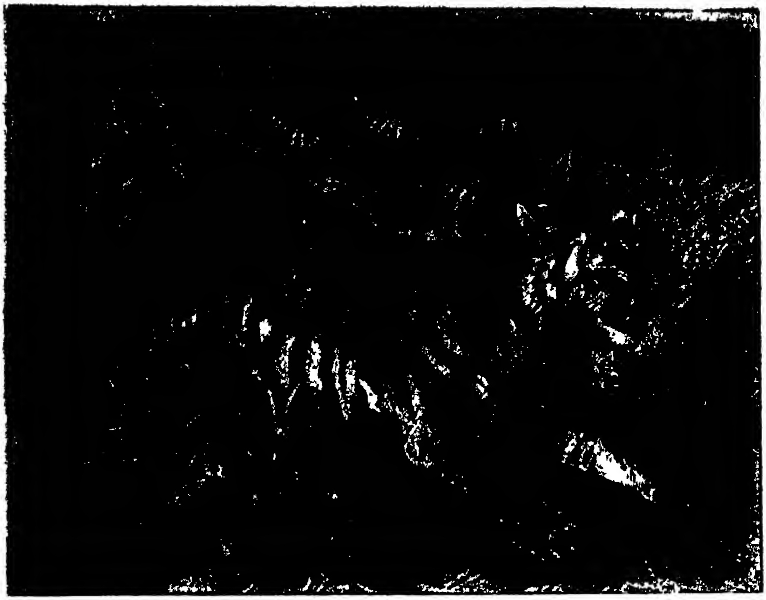


Fig. 1234.—Tiger (*Felis tigris*)

heard of, or, if heard of, rarely survive long. Before there were so many European sportsmen as there now are in the country, a man-eater frequently caused the temporary abandonment of whole tracts; and the sites of small hamlets abandoned by the terrified inhabitants, and which have never been reoccupied, are not uncommonly met with by the sportsman in the jungles. The terror inspired by a man-eater throughout the district ranged by him is extreme. The helpless people are defenceless against his attacks. Their occupations of cattle-grazing or wood-cutting take them into the jungles, where they feel that they go with their lives in their hands. A rustling leaf, or a squirrel or bird moving in

the undergrowth, sets their hearts beating with a dread sense of danger. The only security they feel is in numbers. Though the bloodthirsty monster is perhaps reposing with the remains of his last victim miles away, the terror he inspires is always present to every one throughout his domain. The rapidity and uncertainty of a man-eater's movements form the chief elements of the dread he causes. His name is in every one's mouth; his daring, ferocity, and appalling appearance are represented with true Eastern exaggeration; and until some European sportsman, perhaps after days or weeks of pursuit, lays him low, thousands live in fear day and night. Bold man-eaters have been known to enter a village and carry off a victim from the first open hut. Having lived in a tract so circumstanced until I shot the fiend that possessed it, and having myself felt something of the grim dread that had taken hold of the country-side, where ordinary rambling about the jungles, and even sitting outside the tent after dark except with a large fire, or moving from the encampment without an escort, were unsafe, I could realize the feelings of relief and thankfulness so earnestly expressed by the poor ryots when I shot the Jezebel that had held sway over them so long. The man-eater is often an old tiger (more frequently a tigress), or an animal that, through having been wounded or otherwise hurt, has been unable to procure its usual food, and takes to this means of subsistence.' In a recent article (in *The Sports of the World*) Lieutenant-general Sir Montagu G. Gerard thus speaks on this subject:—"Man-eaters are very rare indeed, and . . . probably become so accidentally. The accepted belief that they are necessarily mangy is a myth; it may be the cause, not the effect. For whatever reason, they seem to acquire preternatural cunning, and natives believe that the soul of a man is imprisoned within them. I once spent a fortnight following one, who never during that time killed within ten miles of her last victim. . . . A former colonel of the C.I. Horse, the most celebrated tiger slayer of thirty years back, killed an exceptionally mischievous one, which in a year had accounted for eighty-seven known victims. . . . I have only killed four undoubted ones, whose victims ranged from thirty-three to about a dozen apiece; but I have known of several others, generally sulky males, who had killed cattle-herds or wood-cutters disturbing them."

Of other members of the Cat family (Felidæ) large enough to

be dangerous to man, it need only be said that, since they are expert climbers, trees afford no refuge to human beings if they chance to be attacked.

Bears (Ursidæ), from their great strength and powerful claws, are dangerous antagonists when roused, but they can scarcely be considered the natural enemies of mankind, for most of them leave human beings alone unless provoked, or impelled by hunger. It may be gathered from accounts of Arctic expeditions, for example, that a hungry Polar Bear (*Ursus maritimus*) will not hesitate to attack men, and similarly for the Brown Bear of Europe (*U. arctos*), and the North American variety of that species commonly known as the "Grizzly". It is rather curious that the Indian Sloth-Bear (*U. labiatus*), which chiefly lives on fruit, honey, and insects, is somewhat given to turning upon our species, though, obviously, not as the result of hunger. At least Sir Samuel Baker says (in *Wild Beasts and their Ways*):—"This species is very active, and although it refuses flesh, it is one of the most mischievous of its kind, as it will frequently attack man without the slightest reason, but from sheer pugnacity". And under these circumstances the long-curved claws are capable of inflicting "terrible wounds upon a human being".

Wolves, when pressed by hunger, are destructive to human life in several countries, their habit of hunting in large packs greatly aggravating the danger, as everyone is aware. The annual casualties due to wolves in parts of the Russian Empire are by no means inconsiderable.

Even without special provocation some of the larger wild Mammals of purely herbivorous habit may injure or kill human beings, as in the case of Hippopotami, Buffaloes, Rhinoceroses, and Elephants. All have heard, for example, of "rogue" Elephants, ill-natured males which have been expelled from their herds for general misbehaviour. But details are here unnecessary. Some of the smaller forms, such as Wild Boars, are also dangerous, and the Peccaries (*Dicotyles*), which range from South America to Mexico and Texas, are even more so. A. G. Requa recounts the following amusing adventure (in *The Big Game of North America*) with a herd of White-lipped Peccaries (*D. labiatus*), which sufficiently illustrates their ferocity:—"I had not sat there more than five minutes before I heard the sharp noise of the Peccaries. They came in sight not more than twenty yards below me. There

were not more than a dozen that I could see, and there were plenty of small pines near by; so I thought that I would just kill the whole herd, provided they showed fight. As they came into the open ground they seemed to wind me, as they began to snuff and paw. I fired at one, and, just as I intended, only crippled him. He set up a great squealing, and, sure enough, here they came! I was just a little excited, and started for a tree, forgetting my coat and turkey. I had scarcely time to get up when they were around the tree, and instead of twelve, they kept coming till there were at least two hundred. I commenced shooting, and killed five with my rifle, that being the number of shells in my gun. It then occurred to me that my rifle-shells were in my coat; so, having no further use for my rifle, and realizing that it would become a burden to me if compelled to stay in the tree several hours, as seemed likely, I threw it down. Fortunately I had both revolvers, and a belt full of cartridges for them; so I went at them. They were chewing the tree, and climbing over each other trying to get at me. Each shot laid one out, and each shot seemed to make them more and more furious, as they would rush at the tree, and gnaw the bark and wood, while the white flakes of froth fell from their mouths. I tried to count them, and found that there were over two hundred left, and I had killed twenty-three. The position I had was not a comfortable one, but I had to stand it. Then for the first time I thought of the boys. Had they heard my shooting? if so, would they come? Then I remembered I had not fired the signal agreed on, and that I had followed the turkeys up the mountain and down again, and by this time the boys must be four miles up the cañon and on the opposite side. The Peccaries showed no signs of leaving. It was now noon, and very warm. They would root around, then come back to the tree, and grunt, and paw, and bite the tree; then they would cool down a little, would go a short distance away, root around awhile, then come back again. I was getting tired of being treed, but it was just what we had planned the night before, only we were not all together. If the boys could only hear my firing, and come over, how quick we would wipe them out! Such thoughts ran through my head; but still the pigs stayed. One o'clock came, then two; still they stayed. Then I thought I would fire a signal with my revolver—maybe the boys were hunting for me; so I made a noise, and back to the tree they came. I killed three

of them in about a second; then I waited. Three o'clock came, then four, and no sign of the boys. Some of the pigs would feed while the others stood guard; then they would change off. I was so tired I could scarcely stay in the tree; so I took my belt off and buckled myself fast to the trunk, so that I would not fall out. Seven o'clock! I could see no change; they still camped near me, showing no signs of weakening. Then the sun went behind the mountain; darkness came on, and I was thirsty, hungry, and tired; but, worse than all, I was a prisoner. Twelve o'clock! The moon shone brightly, and I could see my sentinels scattered around. Two o'clock! Then came a signal from some of the outside ones; the rest snuffed the air, then away they all went. I could hear them far below, going down the mountain. . . . Hereafter, anyone who wants to hunt Peccaries can hunt them, and be blanked; but I prefer some kind of game that is not so fond of human flesh as they are." Without the friendly tree the adventure might have ended differently, for the same writer tells us of these animals that—"If one of their number is wounded so that it squeals, the whole herd becomes ferocious, will charge their enemy on sight, and speedily destroy him, unless he escapes by climbing a tree or by flight".

The blood-sucking Bats have been spoken about elsewhere (see vol. ii, p. 30).

Personal Enemies among Reptiles (Reptilia).—The larger Crocodiles and Alligators are particularly destructive to human life, though their sphere of operations is obviously much limited by their aquatic habits. Speaking of Ega on the Upper Amazons, Bates says (in *The Naturalist on the Amazons*):—"Alligators were rather troublesome in the dry season. During these months there was almost always one or two lying in wait near the bathing-place for anything that might turn up at the edge of the water—dog, sheep, pig, child, or drunken Indian." With reference to Crocodiles in Madagascar, Sibree remarks (in *The Great African Island*):—"They are regarded with a superstitious dread by many of the Malagasy tribes, and are so dangerous in some parts of the island that at every village on the banks of the rivers a space is carefully fenced off with strong stakes, so that the women and girls can draw water without the risk of being seized by the jaws or swept off by the tail of these disgusting-looking creatures". Tales about the ferocity of Crocodiles are sufficiently numerous, many of them, of

course, having reference to that notable species, the Nile Crocodile (*Crocodilus Niloticus*, fig. 1235). The following remarks by Sir Samuel Baker (in *Wild Beasts and Their Ways*) will sufficiently illustrate the point:—"The throat of a crocodile is not only large, but is capable of great expansion, and although the habits of the creature usually permit the body of a victim to rest in quiet until it is devoured in piecemeal, there are many exceptions to the rule; large crocodiles will swallow a small person without the slower operation of dismemberment. . . . When I was in

Fig 1235.—Nile Crocodile (*Crocodilus Niloticus*)

command of the Khedive's expedition, our losses through crocodiles were very distressing, all of which were terrible examples of the ferocity, combined with cunning, which characterizes this useless scourge. On one occasion the vessels were sailing up the White Nile with a strong north wind, making at least 7 knots an hour; one of the cavasses was sitting upon the deck, with his legs dangling over the sides of the deeply-laden vessel, his feet being half a yard above the water. Suddenly a rush was made by a very large crocodile, and the man was seized and carried off in a shorter time than it would take to announce the fact. This was done in the presence of a hundred men on board the vessel, and nothing was ever heard of the unfortunate cavass."

Mention may here be made of the fact that two species of poisonous Lizards exist, both native to North America. One (*Heloderma horridum*, fig. 1236) is a Mexican form, while the other, commonly known as the "Gila Monster" (*H. suspectum*), inhabits New Mexico and Arizona. The sharp curved teeth of these creatures are grooved in front and behind for the purpose of conducting the poison, which is secreted by a series of small glands opening along the edge of the lower jaw. Of the Gila Monster,

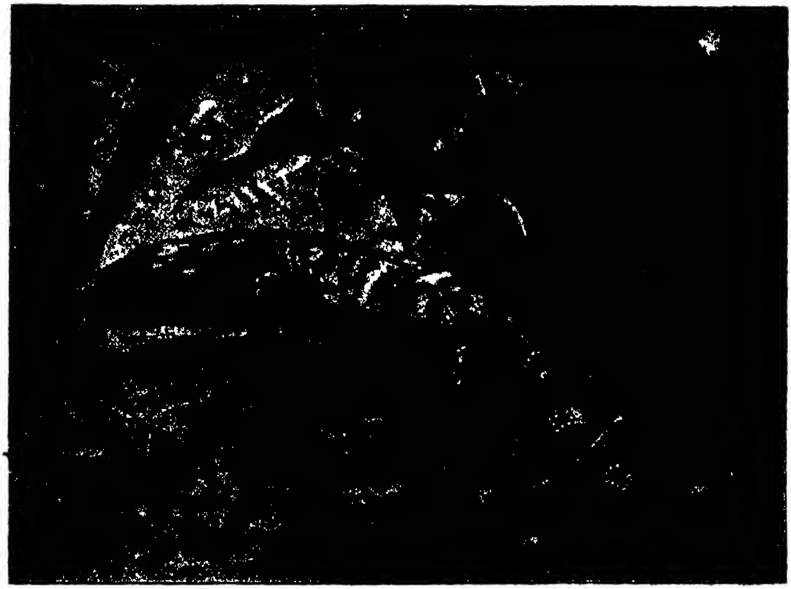


Fig. 1236.—Mexican Poisonous Lizard (*Heloderma horridum*)

Gadow states (in *The Cambridge Natural History*):—"Frogs are probably paralysed or killed by the bite, which, although not so dangerous as that of poisonous snakes, is effective enough to produce severe symptoms even on man, and a few cases of death of people who had been bitten are on record".

Poisonous Snakes are among the most formidable personal enemies of man, and are justly dreaded in the countries they inhabit, which embrace all but the coldest parts of the globe. There is also reason to think that at least one of the larger non-poisonous snakes, *i.e.* the Anaconda or Water-Boa (*Eunectes murinus*) of northern South America, may now and then crush and devour

human beings. This species is said to attain the length of 33 feet, or possibly more.

The mechanism by which a venomous serpent bites its victim, so as to introduce poison into the wound, has been described already (see vol. ii, p. 80), so does not require mention here. In justice to such creatures it may be said that, as a rule, they only attack human beings when interfered with, as, *e.g.*, by being accidentally trodden upon. Among the most dreaded species are the Indian Cobra (*Naia tripudians*); the even more dangerous Krait (*Bungarus cæruleus*), of the same country; the Australian Death-Adder (*Acanthophis antarcticus*); the Coral-Snake (*Elaps corallinus*) of tropical South America; the Sea-Snakes (*Hydrophinæ*) of the Indian Ocean; the African Puff-Adder (*Vipera arietans*); Russell's Viper (*V. Russelli*), native to South Asia; and the American Rattle-Snakes (species of *Crotalus*). The following remarks by Semon (in *In The Australian Bush*) will prove of interest:—

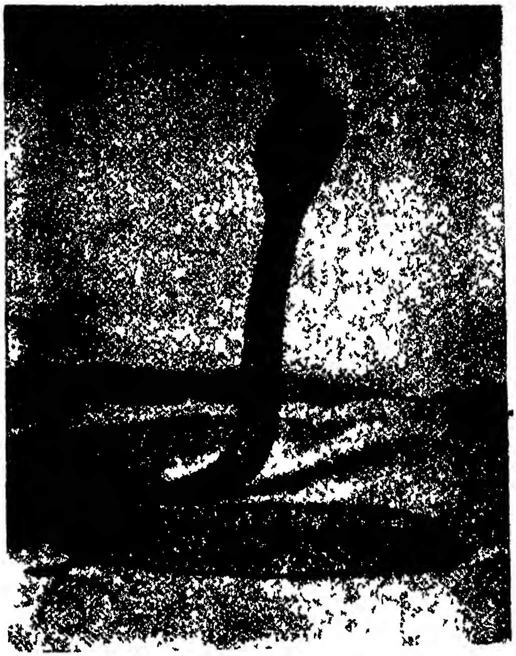


Fig 1237.—Indian Cobra (*Naia tripudians*)

"It is decidedly no exaggeration to say that 500 persons are yearly bitten on the Australian continent, although the majority of these cases do not prove fatal. The population of Australia is at present supposed to amount to 3,000,000 [in 1901 it was nearer 4,000,000]. About 20,000 deaths by snake-bite are yearly reported from the British provinces of India, containing 120,000,000 inhabitants [population of India in 1901 was 294,266,701]. This record may indeed be somewhat exaggerated, and may owe its

enormity to conscious or unconscious deception of the magistrates by the native officials. Decidedly, however, the figures are not so much overrated as is frequently believed. In India, as well as in Australia, in the course of a year about one person in 6000 falls a victim to snake-bite."

PERSONAL ENEMIES AMONG FISHES (PISCES).—Some of the larger Sharks injure or devour bodily a good many human beings every year. The most notable is the Rondeletian Shark (*Carcharodon Rondeletii*), which ranges through the warmer parts of the ocean, and may attain the length of 40 feet.

Those fishes also which possess poisonous spines (see vol. ii, p. 355) may cause serious injury, while some species are poisonous as food, such, *e.g.*, as Globe-Fishes (*Diodon* and *Tetrodon*) and Coffer-Fishes (*Ostracion*).

Fig. 1238.—A Gnat (*Culex*), enlarged

PERSONAL ENEMIES AMONG MOLLUSCS (MOLLUSCA).—Some of the giant Squids, and larger creatures of the Octopus kind, are certainly capable of injuring or destroying human beings. How far they do so, or have done so, it is impossible to say. And a few Sea-Snails, such as Cone-Shells (see vol. ii, p. 357), give poisonous bites.

PERSONAL ENEMIES AMONG INSECTS (INSECTA).—It is quite impossible here to pass in review the host of insects which bite or sting, and many of which make up by numbers what they lack in size. Bees, Wasps, Ants, Gnats (fig. 1238), Mosquitoes, Midges, Sand-Flies, Fleas, Bugs, and Lice are all more or less notable in their way, or perhaps notorious would be a better word. And many insects which do not bite or sting may nevertheless be a serious nuisance, *e.g.* House-Flies and Flesh-Flies.

But a fresh and unwelcome interest attaches to insects now that it is known that some of them are the means of conveying the germs of serious disease into the human body. The recent

work of Major Ross in reference to malarial fever is the best illustration that can be given. It appears that a particular sort of Mosquito (*Anopheles*) is infested with certain stages in the life-history of a parasitic animalcule (*Hæmamœba*) which are introduced into the blood of persons bitten. Further development is there possible, serious disturbances of the system resulting. And when the mosquito bites a human being whose blood harbours these further stages it is in turn infected. In short the mosquito infects man, and man infects the mosquito. Some of the details are given in fig. 1239. Fortunately the researches of Ross enable preventive measures to be adopted. The early part of the life of the insect is passed in stagnant water (compare vol. iii, p. 403), from which the immature stages can be cleared out by the use of petroleum, if applied at a suitable time. The method has been exceedingly successful at Havannah, formerly a great breeding-ground for yellow fever and other disorders of malarial type. The subject suggests another homily on the necessity for properly endowing scientific research.

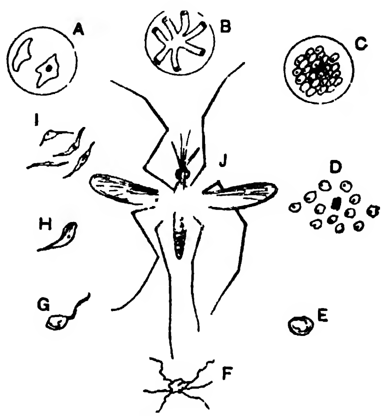


Fig 1239 —Malaria Parasite (*Hæmamœba*)

A, Two parasites within a red blood corpuscle of man; B, one of the same branching C, division of same into minute spores D, spores liberated by breaking up of the corpuscle when taken up into the body of the mosquito with human blood some spores assume the form E, others the form F G shows fusion of an E-spore with a thread from an F spore, H, the fusion is complete, and at this stage the parasite pierces the wall of the mosquito's digestive tube, after complex changes the parasites reach the salivary glands of the insect, where the stage I is produced, which is introduced into the blood of a human being and attacks the red corpuscles J, the mosquito (*Anopheles*) All but J greatly enlarged

Personal Enemies among Spider-like Animals (Arachnida).—It need only be noted that Scorpions possess poisonous stings, while some of the larger Spiders inflict poisonous bites. At one time an exaggerated virulence was ascribed in Italy to the latter. Violent exercise was the reputed cure, hence the origin of the rapid dance known as a "Tarantella" (*i.e.* the diminutive of "Tarantula", the name of the spider).

The unpleasant skin-disease known as "Itch" is caused by the attacks of a kind of Mite (*Sarcoptes scabei*, see p. 196).

Personal Enemies among Myriapods (Myriapoda).—The

large Centipedes (Scolopendra) which abound in tropical countries are well known on account of their painful and poisonous bites.

PERSONAL ENEMIES AMONG ANNELIDS (ANNELIDA).—Some of the Leeches, especially the Land-Leeches of tropical countries, are peculiarly unpleasant to encounter (see vol. ii, p. 148).

PERSONAL ENEMIES AMONG FLAT-WORMS (PLATYHELMIA).—Among the Flukes (*Trematoda*) about eleven different species have been described as parasitic in human beings, including the kind which causes "liver-rot" in sheep, and which will be the subject of further notice. On one notorious scourge of the sort (*Bilharzia hæmatobia*) Gamble remarks as follows (in *The Cambridge Natural History*):—"This formidable parasite was discovered by Bilharz in 1853 in the veins of the bladder of patients at the Cairo Hospital, and is remarkable from its abundance on the east coast and inland countries of Africa from Egypt to the Cape, as well as in the districts bordering Lake Nyassa and the Zambesi river, while westwards it occurs on the Gold Coast. Mecca is a source of infection whence Mohammedans carry the disease to distant places. In Egypt about 30 per cent of the native population is affected by the serious disease known as hæmaturia, resulting from the attacks of *Bilharzia*, so that, of the many scourges from which in Africa man suffers, this one is perhaps the most severe."

A number of Tape-Worms (*Cestoda*) infest the human subject, and one example has been given in an earlier volume (vol. i, p. 441), *i.e.* the Common Tape-Worm (*Tænia solium*), which is a common consequence of eating "measly" pork in a partially cooked condition. Another not infrequent human parasite in Western Europe is the Beef Tape-Worm (*Tænia saginata*), derived from "measly" beef. The Broad Tape-Worm (*Bothriocephalus latus*), which is well known as a parasite of man in Russia, Switzerland, North America, and Japan, results from eating diseased fish, especially pike, which have not been sufficiently cooked. All these three forms attain their adult state in the human intestine, from which they can be expelled with comparative ease by suitable drugs. Another tape-worm (*Tænia echinococcus*) which when adult is found in the dog's intestine, is a much more dangerous parasite to man, in whom it may occur in its earlier bladder-worm form of existence as a swelling or cyst in the lungs or liver (*Echinococcus veterinorum*, fig. 1240), often with fatal consequences.

Pigs and ruminants are also liable to the disease. Gamble says of the bladder-worm stage (in *The Cambridge Natural History*):—"*Echinococcus* is most frequent in Iceland, where it affects 2 to 3 per cent of the population, and a still larger proportion of sheep; while in Copenhagen, Northern Germany, some districts of Switzerland, and Victoria it is not uncommon, but is frequently found during *post-mortem* examinations when no definite symptoms of its presence had been previously noticed."

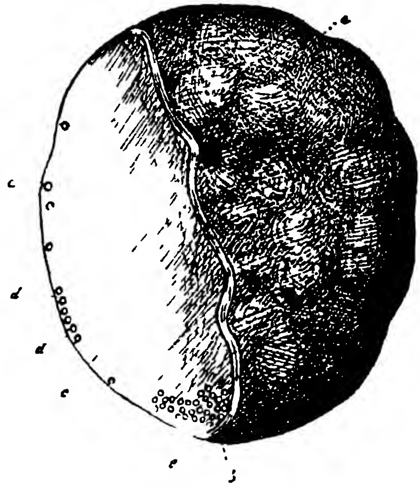


Fig 1240—Echinococcus Cyst from the Liver of a Cow

a Outer covering of cyst, which has been cut away along b to show the cyst itself c d, d d, secondary cysts each of which may produce several tape worms Reduced

PERSONAL ENEMIES AMONG ROUND-WORMS (NEMATHELMIA).—A number of species of these objectionable forms are found as internal parasites within the bodies of human beings. The Round-Worm (*Ascaris lumbricoides*) and Thread-Worm (*Oxyuris vermicularis*) are two of the commonest sorts. Far more dangerous than these is one of the Palisade-Worms (*Dochmius duodenalis*), which possesses spines in the neighbourhood of the mouth, enabling it to burrow in the wall of the small intestine of its host. This worm is the cause of the fatal disease called "miners' anæmia".

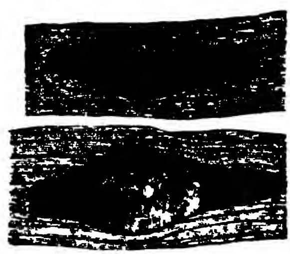


Fig. 1241—Trichinæ encysted in Muscle. Much enlarged

The Guinea-Worm (*Filaria medinensis*), only too well known in tropical countries, is the cause of serious tumours, especially in the legs. These are caused by the female, an elongated (usually 20 to 32 inches) slender creature which lives under the skin of the person affected.

Trichinosis is an extremely dangerous disorder contracted by eating diseased pork, containing the encapsuled stage of a minute

thread-worm (*Trichina spiralis*, fig. 1241). On reaching the human stomach the capsules are dissolved, the minute worms become adult, and myriads of larvæ are produced, which bore into the walls of the intestine. They are then carried in the blood to different parts of the body, especially the muscles, where they come to rest, and pass into the encapsuled stage. Pigs contract the complaint by eating diseased rats, or the offal from their slaughtered fellows, if the latter are infected.

PERSONAL ENEMIES AMONG HEDGEHOG-SKINNED ANIMALS (ECHINODERMATA).—Unpleasant wounds may be given by the long sharp spines of some sea-urchins, especially when these are provided with poison-glands (see vol. ii, p. 361).

PERSONAL ENEMIES AMONG ZOOPHYTES (CŒLENTERATA).—The larger Jelly-Fishes, such as the Portuguese Man-of-war (*Physalia*), possess innumerable nettling capsules, by which they can inflict painful stings, of which the effects may long be felt.

PERSONAL ENEMIES AMONG ANIMALCULES (PROTOZOA).—These are probably more numerous than at one time suspected. The malaria-parasites introduced by means of Mosquitoes (see p. 341) are the most serious at present known.

CHAPTER LXXI

ANIMAL FOES—FORMS INJURIOUS TO HUMAN INDUSTRIES

A large volume would be required to give anything like an adequate account of the innumerable animal pests which more or less diminish the success of many human operations. Keepers of stock or poultry, crop-growers, gardeners, foresters, and the like, all have constant and painful experience of some such forms. Other animals damage buildings, food, clothes, and various manufactured articles. To cope successfully with many of these foes requires much knowledge of their habits and life-histories, and such knowledge can only be acquired by patient and long-continued scientific research, carried out by trained experts. Although an increasing amount of this kind of work is done in the United Kingdom, we are at present very far behind such countries as Germany and the United States, where the value of research is fully appreciated by the authorities. Our own government is comparatively apathetic in the matter, and our universities are too much occupied in turning out graduates by the score to undertake more than a small fraction of the original investigations upon which the prosperity of many of our industries ultimately depends.

It is only possible here to briefly review the animal kingdom with a view to pointing out some of the more injurious forms.

INJURIOUS MAMMALS (MAMMALIA)—It goes without saying that the carnivores which attack man (see p. 331) are still more mischievous by way of raiding flocks and herds. Besides which, members of the same group which are not powerful enough to be considered our own personal enemies, may nevertheless be very destructive to domesticated animals. Foxes, Weasels, and Stoats may be mentioned in illustration. But at the same time it ought to be remembered that the damage inflicted is not

infrequently balanced, or even outweighed, by benefits conferred in other ways (see p. 325)

Cultivated plants are often injured or destroyed by herbivorous or omnivorous Mammals—Deer and various gnawing mammals, such as Rats, Mice, Voles, Hares, and Rabbits. Such creatures may also be injurious in gardens, orchards, and woods, by injuring the bark of trees. In this respect Goats are particularly destructive. A remarkable instance of this is given in the following passage from Wallace (*Island Life*):—"When first discovered [over 400 years ago], St. Helena was densely covered with a luxuriant forest vegetation, the trees overhanging the seaward precipices and covering every part of the surface with an evergreen mantle. This indigenous vegetation has been almost wholly destroyed; and although an immense number of foreign plants have been introduced, and have more or less completely established themselves, yet the general aspect of the island is now so barren and forbidding, that some persons find it difficult to believe that it was once all green and fertile. The cause of the change is, however, very easily explained. The rich soil formed by decomposed volcanic rock and vegetable deposits could only be retained on the steep slopes so long as it was

Fig 1242.—Common House Mouse (*Mus musculus*)

protected by the vegetation to which it in great part owed its origin. When this was destroyed, the heavy tropical rains soon washed away the soil, and has left a vast expanse of bare rock or sterile clay. This irreparable destruction was caused in the first place by goats, which were introduced by the Portuguese in 1513, and increased so rapidly that in 1588 they existed in thousands. These animals are the greatest of all foes to trees, because they eat off the young seedlings, and thus prevent the natural restoration of the forest. They were, however, aided by the reckless waste of man."

Rats, Mice (fig. 1242), and other small rodents are destructive to stored grain and other commodities, and may become a thorough nuisance in dwellings, as most of us have found by experience. Such creatures may also be productive of serious harm by disseminating various diseases. Rats, for example, often cause trichinosis in swine (see p. 344), and hence indirectly in human beings, or may spread such virulent germs as those of bubonic plague.

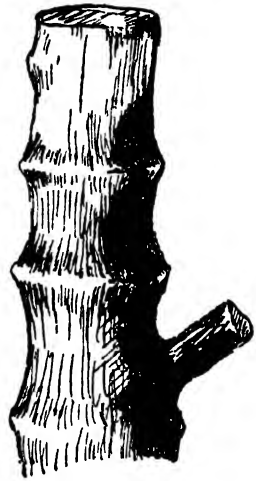


Fig. 1243.—Tree 'ringed' by a Woodpecker

Injurious Birds (Aves).—Large birds of prey, such as Eagles, may attack various domesticated animals, and even the Raven (*Corvus corax*) is known to injure lambs, among other forms. The Kea Parrot (*Nestor notabilis*) of New Zealand has acquired the reprehensible habit of killing sheep by biting deep holes in their backs, its object being said to be to reach the fat in the neighbourhood of the kidneys. The smaller Birds of Prey may raid poultry-yards or game-preserves, and some of them destroy useful insectivorous birds. Certain species, however, do more good than harm (see p. 327).

Among insectivorous birds the Woodpeckers damage trees in the course of their search for food (fig. 1243), and also sometimes by excavating nesting-holes in sound trunks. A great many plant-eating or omnivorous birds do much mischief in cultivated fields, gardens, and orchards, the exact nature of the depredations depending upon the species. Most, if not all, omnivorous birds also do a certain amount of good, sufficient, in some cases, en-

tirely to outweigh their misdeeds. Crows, Rooks, and Sparrows are among the most hurtful forms in Western Europe. Some of the mainly beneficial species are: Thrushes, Starlings, and Chaffinches.

INJURIOUS REPTILES (REPTILIA).—It is only necessary to note that Crocodiles, Alligators, and poisonous Snakes destroy a number of domesticated animals.

INJURIOUS FISHES (PISCES).—Some of the more voracious freshwater forms, especially the Pike (*Esox lucius*) destroy other species of greater value, or interfere with the work of fish-culture. Skate and Rays are destructive to oysters.

INJURIOUS MOLLUSCS (MOLLUSCA).—Forms like the Octopus and its kind destroy oysters, as also do several species of boring sea-snail. Of the latter the "whelks" detrimental to British oyster-culture are chiefly the Common Whelk (*Buccinum undatum*), the Dog-Whelk (*Nassa reticosa*), and the Purple-Shell (*Purpura lapillus*). Various North American species which do harm in the same way are popularly known as "drills".

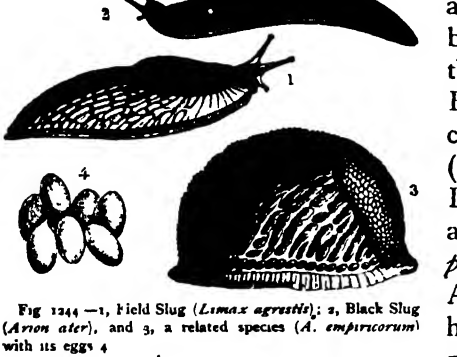


Fig 1244.—1, Field Slug (*Limax agrestis*); 2, Black Slug (*Arion ater*), and 3, a related species (*A. empiricorum*) with its eggs 4.

Cultivated plants of almost all kinds are liable to the attacks of various Land-Snails and Land-Slugs (fig. 1244), which are probably by far the most injurious of all molluscs from the human stand-point.

Among injurious bivalves the Ship-Worm (*Teredo navalis*) is notorious for the way in which it has damaged the timbers of ships and wooden piles. At one time it worked such devastation in the sea-dykes of Holland that serious disaster was threatened. The Edible Mussel (*Mytilus edulis*) is sometimes an enemy to oyster-culture, as it may cover up and smother beds of young oysters.

INJURIOUS INSECTS (INSECTA).—These are so excessively numerous, and at the same time so destructive, that they are the subject of a particularly extensive literature, and constantly engage the attention of many skilled naturalists, especially at the numerous experimental Entomological Stations of America.

Domesticated animals are attacked by a great variety of insects, of which only a few can be here mentioned. Something has elsewhere been said about Bot-Flies (see p. 191). Two such forms, the Ox-Warble Flies (*Hypoderma bovis* and *H. lineatus*, fig. 1245), lay their eggs on the legs of cattle, usually near the heels. It is probable (but not absolutely certain) that the maggots when hatched pierce the skin, under which they make their way to the back. At any rate they are found in that region later on, living in swellings ("warbles") which open to the exterior. Of the injuries inflicted Somerville says (in *Farm and Garden Insects*):—"The damage done by this insect is enormous, the Newcastle Hide Protection Society, for instance, reporting that the hides dealt with in that town alone in 1892 had been damaged by warbles to the extent of £14,000. Besides the injury to the leather *H. bovis* causes great damage by unsettling cattle and preventing them thriving properly. When cattle discover that the fly is hovering near they rush wildly about the field; and the constant irritation to which the larva subjects them when located in the skin is no less detrimental to the animals. The flesh in the neighbourhood of the warbles is also much reduced in value, being covered by a jelly-like substance known as 'licked beef'."

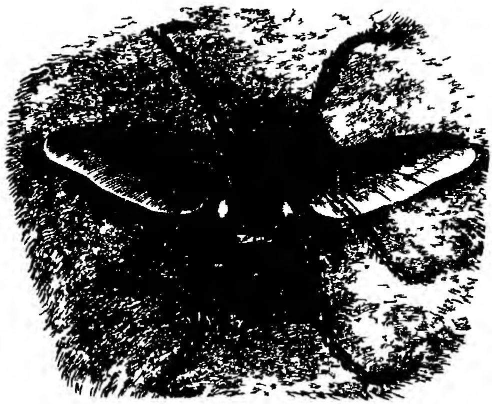


Fig 1245.—Ox Warble Fly (*Hypoderma*) enlarged

The bite of the much-dreaded Tsetse Fly (*Glossina morsitans*) of tropical Africa is fatal to horses, producing "nagana" or "fly-sickness" (see p. 241). This is because the bite introduces into the horse's blood certain stages in the life-history of a parasitic animalcule (*Trypanosoma*), which attacks the red corpuscles. Other biting flies may introduce fatal germs, as, *e.g.*, the bacilli which are the cause of anthrax (splenic fever, quarter evil).

The insect pests which damage stock are mostly Flies and

Fleas (*Diptera*), but forms extremely injurious to cultivated and other plants are to be found in several orders, as a brief summary will show. It will be convenient to mention at the same time some of the species which damage food, clothing, buildings, &c. &c.

Bugs (*Hemiptera*).—By means of their piercing and suctorial mouth-parts innumerable members of this order are able to feed upon the sap of plants, often with the most deplorable consequences. Aphides or Green-Flies (*Aphidæ*) and Scale-Insects or Mealy Bugs (*Coccidæ*) are among the most mischievous, for though of small size they are astoundingly pro-

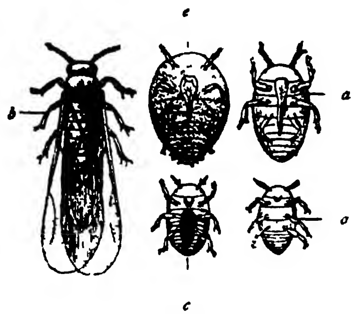


Fig. 1246.—Vine Aphis (*Phylloxera vastatrix*).

a, Wingless root-sucking female; *b*, winged overground female; *c*, wingless overground female; *d*, male; *e*, gall-producing female.

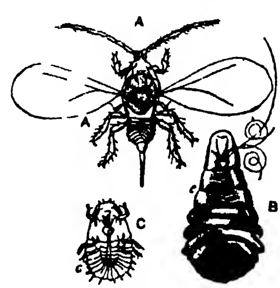


Fig. 1247.—Apple Scale Insect (*Mytilaspis pomorum*), enlarged. A, Male; B, Female; C, Nymph.

lific. Aphides are often popularly known as "blight", and nearly 200 species of them are British, while some 800 have altogether been described. Many important cultivated plants are infested by particular kinds of Aphis, as will be gathered from the names of the following:—Corn Aphis (*Aphis cerealis*), Oat Aphis (*A. avenæ*), Bean Aphis (*A. fabæ*), Cabbage Aphis (*A. brassicæ*), Turnip Aphis (*A. rapæ*), Hop Aphis (*A. humuli*), Cherry Aphis (*A. cerasi*), Plum Aphis (*A. pruni*), &c. &c. Enormous damage is done in vineyards by the Vine Aphis (*Phylloxera devastatrix*, fig. 1246). During the spring and summer wingless females work havoc upon the roots, which swell up into small galls. They lay unfertilized eggs, which hatch out into forms like themselves, and there may be as many as eight generations of the kind produced during the season. But the last batch of these eggs produced in autumn gives rise to wingless males and winged females, that live above-ground and attack the leaves. The fertilized "winter-

eggs" of this generation survive, lie dormant during the winter, and wingless females hatch out from them in the following spring.

Scale-Insects (*Coccidæ*), of which one kind has already been described (see vol. iii, p. 381), are particularly harmful in fruit-culture. Well known in Britain are—Apple Scale (*Mytilaspis pomorum*), white woolly Currant Scale (*Pulvinaria ribesiæ*), and Gooseberry and Currant Scale (*Lecanium ribis*).

Fringe-Winged Insects (*Thysanoptera*) See vol. i, p. 355.

Flies (*Diptera*).—The most familiar pests belonging to this group are the Crane-Flies or "Daddy-Long-Legs" (*Tipulidæ*), of which there are at least some thirty British species. The larvæ, known as "leather-jackets", are very destructive to the roots of grasses and cereals (fig. 1248). A species which has been responsible for great damage to cereal crops in America is the Hessian Fly (*Cecidomyia destructor*), so called because it is supposed to have been introduced into the New World in 1778 by means of straw brought by Hessian mercenaries. The female fly lays her eggs in pairs in the angles where the leaves of wheat, barley, or rye join the stem. The maggots feed upon the juices of the haulm, causing this to bend or break, and interfering greatly with the development of the grain. The Wheat-Midge (*Cecidomyia tritici*) is chiefly destructive to wheat and rye, the eggs in this case being laid in the flowers. The Frit-Fly (*Oscinis frit*) is injurious to cereals in much the same way as the Hessian Fly, but its eggs are here laid on the under sides of the leaves. Some flies lay their eggs on food, and cause great annoyance. The Blow-Fly or Blue-Bottle (*Musca vomitoria*) and the Cheese-Fly (*Piophila casei*) are well-known examples.

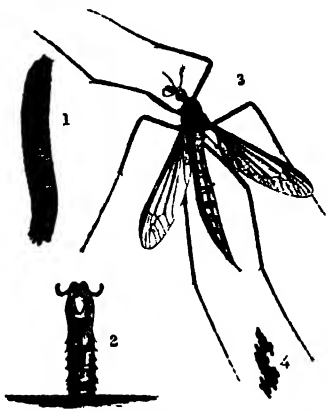


Fig 1248.—Crane Fly (*Tipula oleracea*) 1, Larva; 2, pupa, 3, adult, 4, eggs

Moths and Butterflies (*Lepidoptera*).—Almost everyone has noticed the way in which the caterpillars of these insects voraciously devour plants of various kind, and a mere list of destructive species would occupy a considerable space. Among injurious

Butterflies the Whites (*Pieridæ*) are only too familiar. They include, for example, the Large Garden White or Cabbage Butterfly (*Pieris brassicæ*), the Small White (*P. rapæ*), and the Green-veined White (*P. napi*). The leaves of cabbages, cauliflowers, turnips, and other cruciferous plants are ravaged by the insatiable caterpillars.

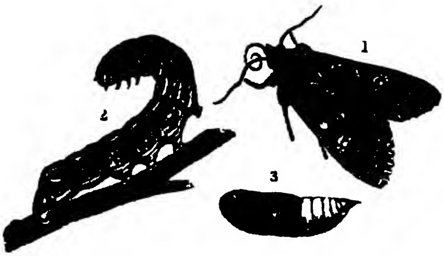


Fig 1249.—Cabbage Moth (*Mamestra brassicæ*) 1, Adult female, 2, larva 3, pupa

The larvæ of many species of Owlet Moths (*Noctuidæ*), under the name of "surface caterpillars", are responsible for a large amount of damage to various cultivated plants. Notable forms are the Turnip Moth (*Agrotis segetum*), Heart-and-Dart Moth (*A. exclamationis*), and Great Yellow Underwing (*Triphæna pronuba*).

Among other species of which the larvæ are destructive to ordinary crops may be mentioned—Silver-Y Moth (*Plusia gamma*), inimical to most cultivated herbs, Cabbage Moth (*Mamestra brassicæ*, fig. 1249), Pea Moth (*Grapholitha nebritana*), the caterpillars of which penetrate the young pods and feed on the immature peas; Grass Moth (*Charæas graminis*), a


Fig 1250.—Codlin Moth (*Carpocapsa pomonella*) Adult female on left, larva in centre pupa to right its actual size indicated by a line)

pasture pest; and Diamond-back Moth (*Plutella cruciferarum*), destructive to various crucifers.

Various trees of economic importance are liable to be attacked by voracious caterpillars. What are known as "worm-eaten" apples, for instance, commonly owe their condition to the larvæ of the Codlin Moth (*Carpocapsa pomonella*, fig. 1250). The large caterpillars of the Goat Moth (*Cossus ligniperda*) bore great holes in forest-trees, while the larvæ of other species ravage their

foliage. The Nun (*Psilura monacha*) is a very serious forest pest in Germany, for its caterpillars devour pine-needles and the leaves of hardwood trees in a wholesale manner. The Gipsy Moth (*Ocneria dispar*), introduced from Europe into the United States some thirty years ago, has within the last decade proved a veritable scourge to many trees. Fletcher Osgood makes the following observations about this particular pest (in *Harper's Magazine*, 1897):—"The careful reckoning of science has demonstrated that the unrestricted caterpillar increase of a single pair of gipsy moths would suffice in eight years to devour the entire vegetation of the United States. In the ordinary course of nature (let Heaven be thanked for it!) such increase is never left wholly unrestricted. . . . Since the work [of extermination] began [in Massachusetts], some forty-two millions of trees have been inspected, while the number of the buildings, walls, and fences thus looked over exceeds four hundred thousand. Besides myriads of the gipsy kind destroyed by burning and in other ways, and hosts escaping record in the first years of the outbreak, the force employed against the caterpillar has killed directly by hand, to date, about two billions and three millions of these dreadful creatures. The unrecorded destruction will doubtless bring the list of killed to at least some four billions. The results so far have more than justified the necessary outlay."

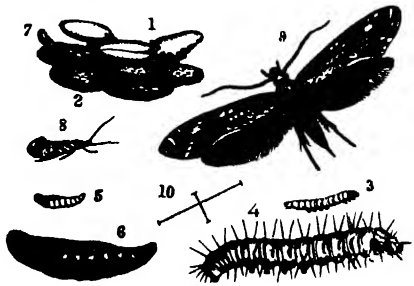


Fig. 1251.—Corn Moth (*Tinea granella*). 1, Infested grains held together by threads of silk; 2, cocoons; 3, larva; 4, the same enlarged; 5, chrysalis; 6, the same, enlarged; 7, empty chrysalis skin projecting from cocoon; 8, adult female; 9, the same, enlarged (actual size in same position indicated at 10)

The Corn Moth or Corn Wolf (*Tinea granella*, fig. 1251) is a small granary-pest that does much damage to stored grain. The Clothes-Moths, so destructive to garments of cloth and fur, are closely related.

The last species to be here mentioned is the Wax Moth (*Galleria mellonella*), one of the enemies of apiculturalists. The female tries to enter a bee-hive, and, if successful, lays her eggs there. When the caterpillars hatch out they burrow into the combs, and feed upon the wax.

Injurious Beetles (*Coleoptera*).—Many notorious malefactors belong to this order. Among the most injurious are "wire-worms", which do great damage to the underground parts of cereals, grasses, and root-crops, and are no other than the larvæ of the little Click-Beetles (*Elateridæ*). The still smaller Turnip Flea-Beetles (*Haltica nemorum*, fig. 1252, and *H. undulata*), popularly known as Turnip-"Flies", are very injurious to turnips and related plants, for the adults attack the leaves from the outside, while their larvæ burrow within them. Some of the "Chafers" are very injurious to trees, crops, and pastures. The Common Cockchafer (*Melolontha vulgaris*), when adult, ravages the foliage of trees, while its grubs live underground, and attack the roots of grasses, various crop-plants, and many trees. A form which created a "scare" in this country some years ago is the Colorado Beetle (*Chrysomela decemlineata*), a particularly prolific insect which, both in the larval state and when adult, devours potato leaves.

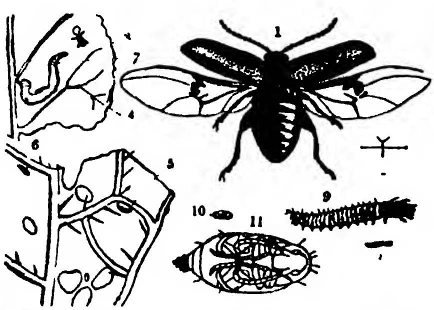


Fig 1252.—Stages of Turnip Flea Beetle (*Haltica nemorum*). 1, Adult (enlarged), showing wing covers and wings spread out. 2, 3, natural size of same. 4, 5, eggs (5 enlarged). 6, 7, burrows of larvæ (7 enlarged) 8, 9, larva (natural size and enlarged) 10, 11, pupa (natural size and enlarged)

The larvæ of Beetles belonging to one family (*Bruchidæ*) burrow in seeds, and some of them infest plants of economic value, *e.g.* Pea-Beetles (*Bruchus pisi*) and Bean-Beetle (*B. fabæ*).

The little long-snouted Weevils (*Curculionidæ*), of which something like 20,000 species have already been described, include a large number of pests, of which both adults and larvæ feed on vegetable matter. The Pea-Weevil (*Sitones lineatus*), for example, devours the leaves of pea, bean, clover, &c., while its larvæ prey upon their roots. The Apple-blossom Weevil (*Anthonomus pomorum*) is very destructive in orchards to both apple and pear. The female insect deposits her eggs in the young flower-buds, one in each, and may carry on this injurious operation for two or three weeks. The Corn-Weevil (*Calandria granaria*, fig. 1253) bores holes in young grains of corn, and each of the some 150 eggs of a single female are deposited within separate grains. Some of

the Weevils are among the pests of forestry, certain forms attacking conifers, *e.g.* species of *Hylobius* and *Pissodes.*

Some of the Beetles are indoor pests, their larvæ feeding on all sorts of substances. The members of one small family (*Dermestidæ*) devour animal substances, and are very destructive in museums. To one species at least (*Anthrenus fasciatus*) the horse-hair coverings of furniture prove palatable. The larvæ of the Bacon-Beetle (*Dermestes lardarius*) indulge in a more luxurious diet, as the name indicates. The larvæ and adults of certain species belonging to another family (*Ptinidæ*) are not often seen, though some of them are frequently heard, and their "works" are familiar. A kind of literary flavour attaches itself to the Biscuit-"Weevil" (*Anobium paniceum*), for its larva is most likely the "original bookworm" which finds its pabulum in libraries, though paper is not the only item in its bill of fare, for Sharp remarks (in *The Cambridge Natural History*) that ". . . it must possess extraordinary powers of digestion, as we have known it to pass several consecutive generations on a diet of opium; it has also been reported to thrive on tablets of dried compressed meat; in India it is said to disintegrate books; a more usual food of the insect is, however, hard biscuits; weevily biscuits are known to every sailor, and the so-called 'weevil' is usually the larva of *A. paniceum*". The "Greater Death-Watches" belong to allied species (*A. striatum* and *A. tessellatum*), and are the cause of "worm-eaten" wood and much superstition.

Fig. 125. Weevils. 1, Grain of wheat, showing the punctured hole, and 5, the exit of the perfect weevil. 2, Pupa (natural size), 3, magnified. 4, Grain of Indian corn, with weevil inside. 6, 7, Corn Weevil (*Calandra granaria*), natural size and magnified. 8, 9, Rice Weevil (*C. oryzæ*), natural size and magnified.

Injurious Membrane-Winged Insects (*Hymenoptera*).—To farmers and fruit-growers the Saw-Flies are here most deleterious, while Wood-Borers are among the pests of forestry. Their operations have been already sufficiently described (see vol. i, p. 371; vol. ii, p. 203; and vol. iii, p. 386). Prominent pests are the Corn Saw-Fly (*Cephus pygmæus*), Turnip Saw-Fly

(*Athalia spinarum*), Apple Saw-Fly (*Hoplocampa testudinea*), Gooseberry and Currant Saw-Fly (*Nematus ribesii*), Cherry and Pear Saw-Fly (*Eriocampa limacina*), Plum Saw-Fly (*Hoplocampa fulvicornis*), and Pine Saw-Fly (*Lophyrus pini*, fig. 1254).

Other net-winged insects may at times be injurious, *e.g.* Wasps sometimes damage large quantities of fruits, while Ants make raids on provisions (especially those containing sugar), and Carpenter-Bees (*Xylocopa*) destroy woodwork.

Injurious Net-winged Insects (*Neuroptera*).—The Biting-Lice (*Mallophaga*) live as ectoparasites on birds or mammals, and feed on their feathers or hairs, at the same time causing much irritation. Domestic fowls are pestered by no less than five species of these insects, one (*Menopon pallidum*) being particularly common. The

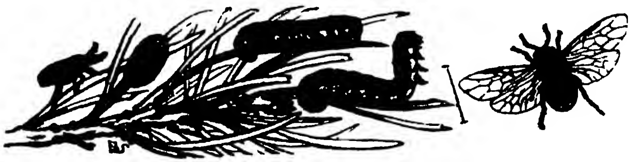


Fig. 1254.—Pine Saw-Fly (*Lophyrus pini*). On the branch to the left are two larvæ, a cocoon, and an adult male; on the right is an adult female, enlarged (actual size indicated by the line).

Biting Dog-Louse (*Trichodectes latus*) not only torments its host but also harbours a stage in the life-history of a tape-worm which lives when adult in the dog's intestine.

In some of the hotter countries of the world Termites or "White Ants" are very harmful to furniture and woodwork, on account of their habit of excavating and feeding upon wood (see p. 120). An interesting example is giving by Sharp (in *The Cambridge Natural History*), who says:—"A Termite (*Termes tenuis*) was introduced—in what manner is not certainly known—to the island of St. Helena, and committed such extensive ravages there that Jamestown, the capital, was practically destroyed, and new buildings had to be erected".

Injurious Straight-winged Insects (*Orthoptera*).—Locusts have been one of the scourges of mankind from the earliest times, owing to their enormous fertility and the wholesale manner in which they devour all sorts of vegetation (see vol. i, p. 382, and vol. iii, p. 379). The species which migrate from place to place in vast swarms are those which do most mischief. The following quotation from Sharp (in *The Cambridge Natural History*)

regarding such forms will give an idea of the possibilities:—"In countries that are liable to their visitations they have a great influence on the prosperity of the inhabitants, for they appear suddenly on a spot in huge swarms, which, in the space of a few hours, clear off all the vegetable food that can be eaten, leaving no green thing for beast or man. It is difficult for those who have not witnessed a serious invasion to realize the magnitude of the event. Large swarms consist of an almost incalculable number of individuals. A writer in *Nature* [Carruthers, 1889] states that a flight of locusts that passed over the Red Sea

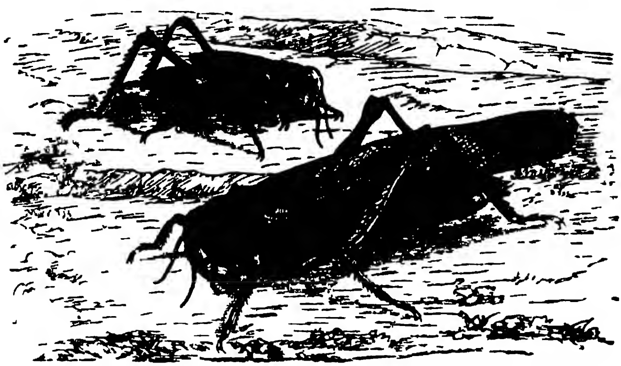


Fig. 1255.—Larva and Adult Female of the Migratory Locust (*Schistocerca peregrina*)

in 1889 was 2000 square miles in extent, and he estimated its weight at 42,850 millions of tons, each locust weighing $\frac{1}{16}$ of an ounce. A second similar, perhaps even larger, flight was seen passing in the same direction the next day. That such an estimate may be no exaggeration is rendered probable by other testimony. From official accounts of locusts in Cyprus we find that in 1881, up to the end of October, 1,600,000,000 egg-cases had been that season collected and destroyed, each case containing a considerable number of eggs. By the end of the season the weight of the eggs collected and made away with amounted to over 1300 tons, and, notwithstanding this, no less than 5,076,000,000 egg-cases were, it is believed, deposited in the island in 1883. When we realize the enormous number of individuals of which a large swarm of locusts may consist we can see that famine is only a too probable sequence, and that pestilence may follow—as it often has done—from the decomposition of the

bodies of the dead insects. This latter result is said to have occurred on some occasions from locusts flying in a mass into the sea, and their dead bodies being afterwards washed ashore."

Of other well-known members of the present order which are to be regarded as pests may be mentioned: The Earwig (*Forficula auricularia*), which attacks flowers and fruits; Cockroaches (our common species is *Periplaneta orientalis*), that are troublesome in houses and on board ships; and the Mole-Cricket (*Gryllotalpa vulgaris*), which is injurious to pasture.

Principles regulating the Methods employed in Combating Injurious Insects.—These are summarized by Ritzema Bos (in *Tierische Schädlinge und Nützlinge*) under (1) Preventive Measures, (2) Curative Measures, (3) Measures which are both Preventive and Curative. It may be well once more to emphasize the fact that to successfully combat harmful insects (and all other pests) an intimate knowledge of their habits and life-histories is essential. There is commonly, for example, some stage in the development of a particular animal which can be exterminated with comparative ease and at relatively small expense. This must be carefully borne in mind, or it may turn out that, financially speaking, "the remedy is worse than the disease".

(1.) *Preventive Measures.*—Sickly plants are in many cases more subject to infestation than healthy ones, and it therefore follows that all the means adopted by farmers, gardeners, and foresters to promote the vigour of the forms with which they are concerned assist in warding off the attacks of injurious insects, &c. It is also well known that seedlings are less able to resist their enemies than plants in a later stage of development, from which it follows that crops should be stimulated to rapid growth at the time when sprouting begins.

One of the benefits to be derived from rotation of crops is to check the ravages of various injurious insects, &c., which only feed upon one or a few kinds of plant. They are often, so to speak, starved out. Clean seed is another important preventive, for without precaution in this direction sowing may mean a distribution of pests as well as plants. And as during part of their existence some noxious forms are harboured in straw, another preventive measure is thereby suggested.

It is also sufficiently obvious that the natural enemies of pests should be protected and encouraged as far as possible. This

particular preventive measure chiefly applies to insectivorous birds and mammals.

(2.) *Curative Measures.*—It is possible to collect and destroy many sorts of pest (see p. 353), although this is usually an expensive matter. The question as to which stage in the life-history of a particular form most readily lends itself to the method is clearly one of great economic importance.

Collection is sometimes facilitated by "luring" pests by means of something which serves to attract them. Slices of potato, for example, have been found to draw large numbers of wire-worms.

Fig. 1256.—Winter Moth (*Cheimatobia brumata*, male (centre), female (right), and chrysalis (left). The vertical lines indicate actual sizes.

Many creatures can be destroyed in the places where they live by means of certain powders and sprays, distributed by various ingenious appliances. Soot, quick lime, "Paris green" (an aceto-arsenite of copper), soap suds, paraffin emulsion, &c. &c., all have their special uses.

(3.) *Measures which are both Preventive and Curative.*—These may be illustrated by "tar-rings", employed in combating the Winter-Moth (*Cheimatobia brumata*, fig. 1256), destructive to fruit-trees, and the Gipsy-Moth (*Ocneria dispar*), which is an enemy to all sorts of trees. In both these species the dormant chrysalis stage is passed through in the ground. As the wings of the female Winter-Moth are small and useless, while the female Gipsy-Moth cannot (or at any rate does not) fly, both of them have to creep up the tree-trunks in order to lay their eggs. This can be prevented by means of a tar-coated band of suitable material fixed round the trees a short distance above the ground. Collection and destruction of moths and eggs naturally follow.

INJURIOUS SPIDER-LIKE ANIMALS (ARACHNIDA).—The only forms of great importance here are the Mites (*Acarina*). Mange- and Itch-Mites, injurious to domesticated animals, have already been mentioned (see p. 196). Poultry are attacked as well as quadrupeds. Fowls are also liable to be infested by Red Fowl-Mites (*Dermanyssus gallinæ*), which suck their blood and set up an intolerable itching.

Domesticated animals are also often attacked by Ticks (*Ixodidæ*), which are able to draw large quantities of blood, and, what is more serious, may convey the germs of disease. Infection by means of one such Tick (*Ixodes reduvius*) is, for example, the cause of "louping ill" in sheep.

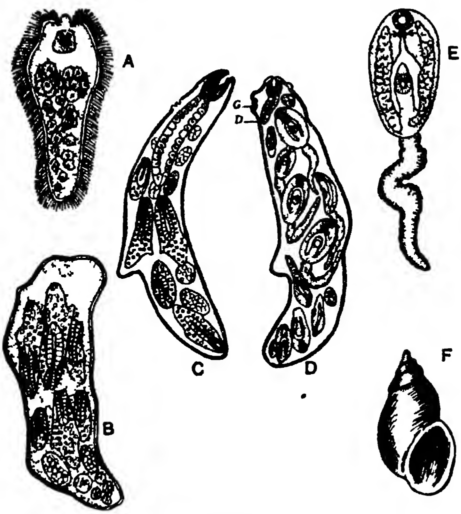


Fig 1257—Stages in Life History of Liver Fluke (*Fasciola hepatica*), enlarged A, ciliated larva F, sporocyst within which rediæ are developing C redia, within which a new generation of rediæ is developing D, redia, with contained cercariæ (G opening by which these escape D intestine) E, cercaria B to E are parasitic within the water snail F *Limnæa truncatula*, from which E escapes to encyst on the stem of a plant

Cultivated plants also suffer from the attacks of Mites, among which the following may be mentioned:—Currant Gall-Mite (*Phytoptus ribis*), Red Hop-"Spider" (*Tetranychus telarius*), Red Plum-"Spider" (*T. rubescens*), and Harvest or Gooseberry-"Bug" (*T. autumnalis*).

Other kinds of Mite spoil furniture and attack food, especially meal, cheese, and sugar.

INJURIOUS MYRIAPODS (MYRIAPODA).—Some of the Millipedes ("false wire-worms") attack the underground parts of various plants, or may damage soft fruits.

INJURIOUS FLAT-WORMS (PLATYHELMIA).—A large number of Flukes (Trematoda) and Tape-Worms (Cestoda) are parasitic within the bodies of domestic animals, as previously stated in dealing with the personal enemies of man (see p. 342). A few details may be appropriately added.

Flukes (*Trematoda*).—It is only necessary here to refer to the

Liver-Fluke (*Fasciola hepatica*, fig. 1257), a brief account of which has already been given (see vol. i, p. 443). The adult Fluke is parasitic in the liver of the sheep, causing the serious disease known as "liver-rot", while certain earlier stages of the life-history are passed within a small water-snail (*Limnæa truncatula*). The following extract from Gamble (in *The Cambridge Natural History*) will give some idea of the serious losses which may be caused by this destructive parasite:—"Over the whole of Europe, Northern Asia, Abyssinia, and North Africa, the Canaries, and the Faroes the fluke and the snail are known to occur, and recently the former has been found in Australia and the Sandwich Islands, where a snail, apparently a variety of *Limnæa truncatula*, is also found. Over these vast areas, however, the disease usually only occurs in certain marshy districts and at certain times of the year. Meadows of a clayey soil, liable to be flooded (as in certain parts of Oxfordshire), are the places where this *Limnæa* occurs most abundantly, and these are consequently the most dangerous feeding-grounds for sheep. The wet years 1816, 1817, 1830, 1853, and 1854—memorable for the occurrence of acute liver-rot in England, Germany, and France—showed that the weather also plays a considerable part in extending the suitable ground for *Limnæa* over wide areas which in dry years may be safe pastures. In 1830 England lost from this cause one and a half million sheep, representing some four millions of money, while in 1879–80 three millions died. In 1862 Ireland lost 60 per cent of the flocks, and in 1882 vast numbers of sheep perished in Buenos Ayres from this cause. In the United Kingdom the annual loss was formerly estimated at a million animals, but is now probably considerably less." This extract clearly shows the importance of scientific research to agriculture, as preventive measures clearly depend upon an accurate knowledge of the life-history of the fluke.

Tape-Worms (*Cestoda*).—The disease of sheep known as "staggers" or "sturdy" is due to the presence of large cysts that cause pressure on the brain, and are the bladder-worm stage (*Cœnurus cerebralis*) of a Tape-Worm (*Tænia cœnurus*) that lives when adult in the intestine of a sheep-dog (fig. 1258). A sheep contracts the disease by swallowing eggs of the parasite which have passed out of the body of a dog, while in its turn a dog becomes infected if it devours cysts from the brain of a sheep that has died of staggers.

Dog and Rabbit (or Hare) are the two hosts of another kind of Tape-Worm (*Tænia serrata*), of which the adult lives in the intestine of the former animal, while the bladder-worm stage (*Cysticercus pisiformis*) is harboured in the body of the latter.

INJURIOUS THREAD-WORMS (NEMATHELMIA).—Many of the worms belonging to this group are injurious to domesticated animals and cultivated plants. The large Horse-Worm (*Ascaris megalocephala*), for example, often infests in great numbers the intestine of the horse and its allies, while smaller species of round-worm live as parasites within dogs and cats. Much more dangerous is the minute Trichina (*Trichina spiralis*) that sets up trichinosis in pig and man (see p. 343).

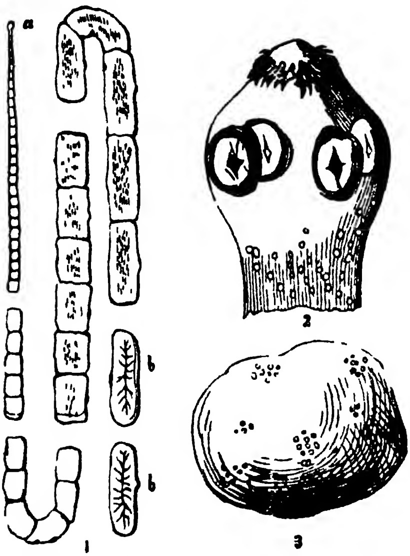


Fig. 1258.—The Tape-Worm (*Tænia cœnurus*), of which the cyst causes "staggers" in Sheep. 1, parts of the adult worm (*a*, head, *bb*, ripe joints), 2, head of same (× 30), showing hooks and suckers, 3, cyst from sheep's brain. Several groups of developing tape-worm heads are indicated.

Much harm is caused by the Palisade-Worms or Strongyles (*Strongylidæ*), related to the species which produces "miners' anæmia" in human beings (see p. 343). The Giant-Strongyle (*Eustrongylus gigas*), of which the female may be from a foot to over a yard long, lives in the kidneys of horse, ox, dog, and, it may be, man. Swellings in the arteries of the horse are caused by the presence of Armed Strongyles (*Strongylus armatus*), while other deadly parasites are the Stomach-Strongyle (*S. contortus*) of the sheep, and the Lung-Worm (*S. filaria*) of the lamb. The disease known as "gapes", to which young poultry and game-birds are liable, is caused by the presence of a related species, the Red- or Forked-Worm (*Syngamus trachealis*).

Some of the little Eel-Worms (*Anguillulidæ*) are serious agricultural pests. They possess a spine at the front end of the body, by which they bore into the tissues of plants. One species, the Wheat Eel-Worm (*Tylenchus scandens*), has been described in

an earlier section (see vol. ii, p. 222). The Stem Eel-Worm (*T. devastatrix*) attacks the stems and leaves of rye, oats, buckwheat, clover, &c., leading to stunted growth, or even killing the plants outright. "Clover sickness" is set up by the presence of this parasite. The Beet Eel-Worm (*Heterodera Schachtii*, fig. 1259) infests the roots of its host-plant, and causes "beet sickness". The related Root-knot Eel-Worm (*H. radicicola*) produces galls on the roots of clover, lucerne, cucumber, tomato, and many other cultivated plants.

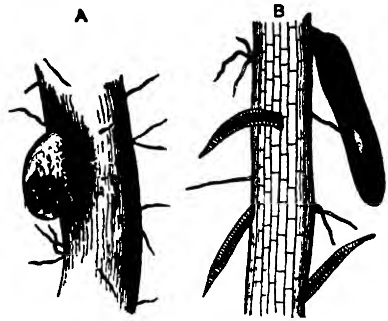


Fig 1259.—Roots of Beet, infested by Beet Eel Worm (*Heterodera Schachtii*) enlarged. A shows a swelling containing adult female, B, larvæ attacking a root

INJURIOUS ANIMALCULES (PROTOZOA).—Nagana or "fly-sickness" (see p. 241) is the best example of disease resulting from the presence of parasitic animalcules in the bodies of domesticated animals.

Some ailments of cultivated plants are also the result of the attacks of certain Protozoa. One instance is afforded by "finger-and-toe" or "anbury", a turnip disease associated with curious deformation of the roots. It is due to the presence of one of the Fungus-Animals (Mycetozoa) within the tissues (i.e. *Plasmodiophora brassicæ*).

CHAPTER LXXII

THE ZOOLOGY OF SPORT

It is hardly necessary to remark that the literature of those forms of "sport" which depend upon the existence of wild animals is very extensive, and includes accounts of experiences and adventures in all parts of the world. Much of it is highly technical, most of it is anecdotal, and but a small part is the work of authors who represent the sportsman and naturalist combined. To name a selection of books for the benefit of expert huntsmen and anglers is of course quite superfluous, but general readers may profitably refer to the following works:—The volumes of *The Badminton Library, Fur and Feather Series*, and *The American Sportsman's Library*; Izaak Walton's *Compleat Angler*; Selous' *A Hunter's Wanderings in Africa*; Sir Samuel Baker's *Wild Beasts and their Ways* and *With Rifle and Hound in Ceylon*; *The Big Game of North America*, *English Sport*, *Sport in Europe*, and *The Sports of the World*, edited respectively by G. O. Shields, Alfred E. T. Watson, and (the two last) by F. G. Aflalo.

We have already had occasion to notice (p. 208) that the first stage in the evolution of civilization was represented by the primeval hunter and fisherman, a stage still in evidence to-day among various savage races. But our remote prehistoric ancestors, like modern savages, were "pot-hunters" rather than sportsmen, while the intimate knowledge they must have acquired of the habits of wild animals imparted a certain flavour of the field naturalist. Many primitive races have also had, and some still have, to defend themselves and (in the pastoral and agricultural stages) their domesticated animals from the attacks of predaceous forms. Even when hunting and fishing were necessary for existence, however, a good deal of pleasurable excitement must have attached to the pursuit of wild animals,

rivalry and emulation playing no unimportant part in the matter. When the further evolution of civilization diminished the material importance of hunting and fishing, these arts continued to be pursued for pleasure as well as for profit; hence the origin of modern sport.

This is not the place to enter into a long disquisition regarding the ethics of field-sports, but such of them as deserve the name involve certain obvious fundamentals. There must be room for skill, the quarry must have a fair chance, and every precaution should be taken to prevent a miserable and lingering death on the part of maimed or wounded animals. The hunter of "big game" would no doubt add that "the greater the danger the greater the sport". Selous, for instance, remarks (in *The Sports of the World*):—"Lion-hunting by savages, armed only with spears or bows and arrows, must have been incomparably more dangerous, and therefore infinitely finer sport, than the pursuit of these animals by civilized man at the present day armed with modern rifles". On the other hand, it is quite possible for a recognized form of sport to become so highly artificial as to demand hardly more skill to make a "bag" than would be required to slaughter the inhabitants of the poultry-yard with a shot-gun. Under such circumstances "massacre" and not "sport" would be the proper word to employ.

Our pluck, vigour, and enterprise as a nation are undoubtedly due in no small degree to the influence of field-sports, and to entirely exclude these from our national life, as some would have us do, on the ground of cruelty to animals, would be as inexpedient as it is impossible. On the other hand, the view of the matter which suggests that it is rather a pleasure than otherwise to be hunted may be regarded as a little optimistic. Lady Augusta Fane, for example, makes the following remarks on fox-hunting (in *English Sport*):—"Worthy folks who fancy that they are more humane than their neighbours write about the cruelty of fox-hunting, drawing fancy pictures of a poor, timid, terrified little creature pursued by savage dogs, ruthless viragoes, and brutal men! As a matter of fact, foxes constantly live to a green old age, and defeat their pursuers season after season. They do not even pretend to be frightened. How often we have seen a fox break out of covert, look around, give himself a good shake, and, whisking his brush, trot off without the

slightest sign of fear! He knows where he means to go, and all the safe refuges *en route*; and if he gets tired he is familiar with the woods, where he can find a friend to take his place."

The limited space here available must necessarily be devoted to briefly reviewing the animals which are of importance from the sporting stand-point, including those which assist man in the chase. Mammals, Birds, Reptiles, and Fishes are the only groups with which we are concerned, though the "naturalist" who hunts down insects or the like merely to add to his collection is more of a sportsman (in a very small way) than a man of science; often, however, he is neither!

MAMMALS (MAMMALIA) AS AIDS TO SPORT

It is a natural consequence of the slow rate of human locomotion that several Mammals have been pressed into the service of man in order to make up for this deficiency, or, it may be, reduce the element of danger. From time immemorial, in many sorts of sport, horse and elephant have saved him the work of using his own legs, while dog or falcon have pursued the quarry and tackled it at close quarters.

THE HORSE (EQUUS CABALLUS).—The combination of intelligence and speed by which the horse is characterized, and its susceptibility to thorough domestication, have naturally led to its large employment in the chase. The extraordinary way in which the long-continued influence of man has resulted in the production of widely different breeds of the same kind of animal is here very strikingly exemplified. A well-bred hunter combines to perfection the two desiderata of speed and endurance, and it is, to all intent and purposes, a product of human ingenuity, without which many forms of sport would be comparatively tame and featureless. It may also be remarked in passing, that without highly specialized breeds of horses certain forms of sport which do not depend upon the existence of a quarry, such as horse-racing and trotting, could never have attained their present high pitch of perfection. By the practice of what may almost be called a species of artificial evolution, man has been here able to further his own ends in a remarkable manner.

THE INDIAN ELEPHANT (ELEPHAS INDICUS).—The use of this animal in tiger-shooting is too well known to need description.

It is here not so much a question of speed as of size and strength, by which otherwise impracticable ground can be traversed, while the personal risk of the sportsman is reduced. On the other hand, an element of different kind is introduced by the nervousness and uncertain temper of the elephant, both of which are decidedly in favour of the quarry.

THE DOG (CANIS FAMILIARIS).—The Dog has been the companion of man in the chase from the remotest times, and to all appearance keenly shares in the exhilarating pleasures of pursuit.

Fig 126a.—Pointer

He has proved singularly susceptible to the selective influence of man, practised for unnumbered centuries, the result of which has been the evolution of a very large number of breeds, many of which have been brought into existence for sporting purposes. We know that the ancient Egyptians possessed several breeds of dogs, one of which was a sort of white hound (see p. 222) used in hunting antelopes, for which sport a similar kind of dog is to this day employed in North Africa. They also used packs of mixed character, though the nature of the breeds is doubtful. Upon the Assyrian sculptures we find hunting-mastiffs and greyhounds figured, while inscriptions inform us that still other breeds existed, some of which appear to have been used in sport.

Sporting Dogs (*Canes venatici*) of various kinds were possessed

by the ancient Romans, some hunting by scent (*nare sagaces*), while others, more fleet (*pedibus celeres*), were let slip when the game was in sight.

To enumerate all the existing breeds employed in sport would be both tiresome and unnecessary. The names of many, *e.g.* fox-hound, deer-hound, and otter-hound, to some extent serve as an indication of their character. The exaggeration of natural instincts in artificial directions would appear to have led to the evolution of "pointers" (fig. 1260) and "retrievers". Darwin suggests that the original act of "pointing" was simply the pause which a carnivorous animal often makes before springing upon its prey.

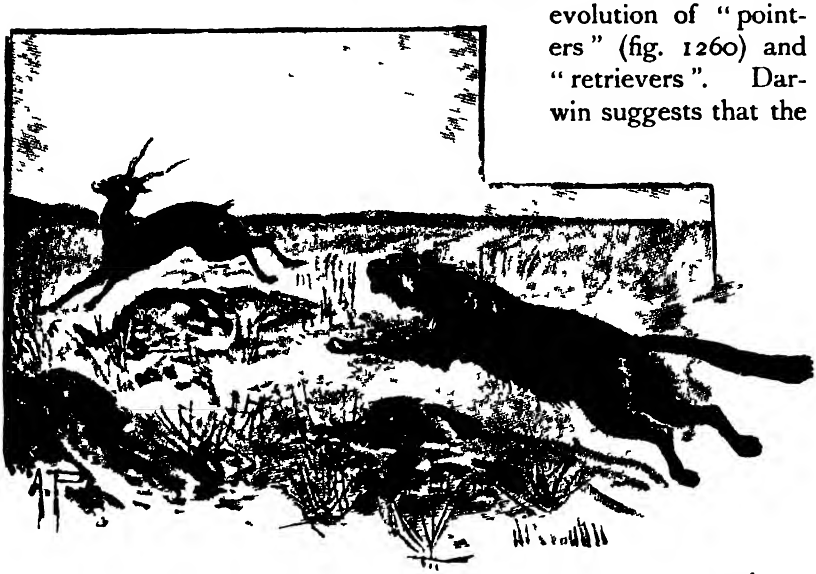


Fig 1261 —Cheetah (*Cynailurus jubatus*) pursuing an Indian Antelope 368-d

It is further interesting to note, that when we employ a pack of hounds to hunt down an animal by scent we are simply making use of the natural methods used by similar forms, when wild, in the pursuit of prey.

The Cheetah, or Hunting Leopard (Cynailurus jubatus, fig. 1261).—This long-legged animal, which is enabled by its fleetness to capture prey in a more straightforward way than is usual among felines, is employed by the native dignitaries of India for coursing antelopes. In former times this variety of sport was practised very largely, and is of ancient origin, having

been known to the Persians so far back as 865 B.C., while at a still earlier period it was familiar to the Assyrians.

THE FERRET.—The slender bodies of the bloodthirsty members of the weasel kind enable them to pursue their prey underground, and advantage is taken of this peculiarity when rabbits are driven from their burrows by means of Ferrets, which are a domesticated variety of the Pole-Cat (*Putorius fœtidus*).

BIRDS (AVES) AS AIDS TO SPORT

Certain Birds of Prey have been employed from very remote times in the pursuit of wild animals, mostly other birds, but the art of Falconry in Europe has steadily declined since firearms came into general use. Another contributing cause has been the gradual increase of the area under cultivation. Lord Granville Gordon (in *Sport in Europe*) thus speaks of the antiquity and wide popularity of this form of sport:—"Records of hawking and falconry are supplied in the writings of Pliny and Aristotle. In Japan, in India, Arabia, Persia, and Syria, we can find it has been practised, and in our own Middle Ages stringent laws were passed referring to it. Hawks and falcons were allotted to men according to their rank and station. An earl had a peregrine, a yeoman a goshawk, a priest a sparrow-hawk, and so on. The king of birds in falconry in our Middle Ages was, and even now is, the peregrine, and the noble game at which to fly this bold and splendid bird was the heron; but I do not think this form of sport is followed any longer in our island." Hawking for rooks or larks is still, however, to be included in the list of British sports.

What may be termed a magnified variety of falconry is practised by the Kirghiz of the Asiatic steppes, the "falcon" in this case being no less noble a bird than the Golden Eagle, while the quarry is often the fox or the wolf (fig. 1262).

MAMMALS (MAMMALIA) HUNTED FOR SPORT

FLESH-EATING MAMMALS (CARNIVORA).—The Lion (*Felis leo*, fig. 1263) is undoubtedly the noblest quarry that falls to the rifle of the sportsman, while the attendant danger and excitement appeal so strongly to those who engage in this form of sport that

it will be popular so long as lions continue to exist. Regarding the antiquity and characteristics of the pursuit Selous makes the following remarks (in *The Sports of the World*):—" Lion hunting must undoubtedly be reckoned amongst the most ancient and

Fig. 126a.—Kirghiz hunting the Wolf with the Golden Eagle

time-honoured of all field-sports, for ages and ages before the days when Assyrian kings pursued the king of beasts for pleasure, and shot him with bow and arrow from their light two-wheeled chariots, the prehistoric races of man, inhabiting the whole of Africa, as well as large areas in Asia and Europe, must have hunted lions as a sporting necessity, in defence of

their flocks and herds as well as of their own lives. . . . Speaking generally, it is a difficult matter to find and hunt lions in the daytime, and shooting them at night cannot be called hunting. Lion hunting on horseback, as it used to be commonly practised in South Africa, is the most exciting form of big game hunting I have had experience of, as lions almost always turn vicious when chased on horseback, and charge freely, and whether you

Fig. 1263.—Lion (*Felis leo*)

are galloping after a lion or a lion is close behind your horse's heels, your nerves are kept strung as long as the hunt lasts. It will be many a long day yet before the lion has ceased to haunt the wilds of Africa, but when that day comes, one of the grandest forms of wild sport will also have become a thing of the past."

The hunting of the Tiger (*Felis tigris*) appears at the present time to be an increasingly rare and expensive form of sport, when conducted in an orthodox way with numerous elephants, some for beating, and others with howdahs for the accommodation of the actual huntsmen. In some parts of India packs of dogs

also help in the sport, and are more feared by the quarry than one would be apt to imagine. Advantage is also often taken of the fact that the tiger is not a climbing animal to shoot him from a secure station in a tree, a goat or buffalo-calf having been previously tied up within easy range to serve as a "bait". Although justifiable for the destruction of man-eaters, this can hardly be dignified by the name of "sport".

The different species of Bear (*Ursus*) are hunted, and also slaughtered in a variety of ways, but do not take a very high place in the estimation of most sportsmen. In parts of Russia,

Fig 1264.—Fox (*Canis vulpes*)

for example, Brown Bears (*Ursus arctos*) are considered to be "vermin". The Lapps, however, do not hesitate to attack this animal in its den, a method sufficiently dangerous and exciting to satisfy the most exacting in such matters.

The European Wolf (*Canis lupus*) is the object of more than one form of popular Russian sport. A favourite variety involves the use of fox-hounds and wolf-hounds, the former being employed for drawing the coverts, and the latter for the actual work of coursing. As previously mentioned (p. 369), the Kirghiz practise a species of falconry, of which the wolf is a favourite quarry.

The Fox (*Canis vulpes*, fig. 1264) is familiar to all as the object of one of the most popular, sociable, and exhilarating forms of British sport, but Lord Granville Gordon tells us (in *Sport in Europe*) that "it is doubtful if fox-hunting can long

continue in a congested country like England. Bad agricultural seasons and barbed wire point to its doom." Otter-hunting is undoubtedly a declining sport in Britain, on account of the increasing diminution in numbers of the quarry.

Elephants (Proboscidea).—Wild Elephants, whether African or Indian, naturally take high rank among "big game", chiefly because their enormous strength, and great ferocity when thoroughly aroused (especially if they are "rogues"), are liable to make them exceedingly dangerous antagonists. But the great perfection to which firearms have now attained render even these great beasts no match for the most destructive member of the Mammalia—Man.

Hoofed Mammals (Ungulata). — Rhinoceroses, of course, reckon as "big game", and, as a rule, seem to be inoffensive enough, though sufficiently dangerous when wounded. Under such circumstances the two-horned White and Black Rhinoceroses of Africa (*Rhinoceros simus* and *Atelodus bicornis*) bring the long front horn into action, while the one-horned Indian species (*R. Indicus*) can bite with terrible effect.

The Hippopotamus (*Hippopotamus amphibius*) is sufficiently formidable when attacked from boats to give it a place among sporting mammals. But to kill it with a rifle from a place of security on the bank of its native river is simply a variety of target-shooting.

Among the many other Ungulates that are pursued for sport some are especially esteemed on account of their pluck and dangerous qualities, *e.g.* the African or Indian Buffaloes and the Wild Boar, while the great speed or agility in climbing of others furnish the requisite zest to the chase, as in the case of Deer, Antelopes, or Ibexes.

The joys and dangers of "pig-sticking", as pursued with reference to the Wild Boar (*Sus scrofa*) of Europe, his Indian cousin (*S. cristata*), and the African Wart-Hog (*Phacochærus*), have been fully described by many authors, and need no mention here. Regarding the Peccaries (*Dicotyles*) of America, something has already been said (see p. 334).

To give here even a brief account of the numerous swift runners or active climbers which belong to the Ungulata, and provide many varieties of sport, is both impossible and unnecessary. Among them the Red Deer (*Cervus elaphus*, fig. 1265) may perhaps

be given first place, at least from the English stand-point, and though the glories of stag-hunting have faded so far as Britain is concerned, innumerable trophies still attest the important place it once held in our national life. Deer-stalking in the "deer forests" of Scotland is excellent sport, but not comparable to hunting the wild animal in the old-time fashion, which, in this country, is now only possible on Exmoor. Regarding a third variety of the sport once popular in Britain Lord Granville Gordon makes the following very apposite remarks (in *Sport in Europe*) --"True we can still pursue him in what might be described as a pickled state, with horns shorn off, around the purlieus of Windsor, or in one or two other places, but, pleasant though the run may actually be, the 'sport' cannot stand close investigation, for sport consists in the strategy and skill of man in pursuing and capturing a wild animal. It loses all its charm and all its poetry when the game is first, as it were, tethered". Wild Red Deer are fortunately more numerous in other parts of Europe, *e.g.* in Hungary, than in Britain, but stalking and driving are in most cases the chief methods employed The following remarks by Paul Caillard (in *The Sports of the World*) are of interest as showing that stag-hunting is to this day practised in France on a considerable scale —"If hunting generally is known as the 'sport of kings', then surely is stag-hunting particularly associated with the memories of mediæval courts, and, although some might not perhaps expect it, modern France preserves above all other lands the tradition and even the outward forms of the ancient *chasse*. . . . In many of our French forests it would be as great a heresy to kill a deer otherwise than before the hounds as ever it would on Exmoor, and many visitors to our meets have expressed their pleasure at the survival of such picturesque sport."

Fig 1265.—Red Deer Trophy

GNAWING MAMMALS (RODENTIA). — Coursing the Hare with gréyhounds is a very ancient form of amusement, which appears to have been indulged in by the Assyrians (fig. 1266). We next hear of it in Greece, and many details are given by Arrian (born

A.D. 90) in his work on coursing. The ancient Gauls were experts in this form of sport, which was probably introduced into Britain from their country. With us, however, it is now almost entirely replaced by hare-hunting with harriers, which supplies much of the interest of fox-hunting at considerably less expense. We know from Xenophon (B.C. 400) that the ancient Greeks in his time pursued the hare with two kinds of dog, the nature of which is doubtful, though they were certainly not greyhounds. It is hardly necessary to add that the sporting value of the Hare is found in its great speed, coupled with considerable ingenuity in "doubling", calculated to baffle even the swift greyhound.

The passion for sport, which is so thoroughly British, is

Fig. 1066. Hares coursed by Greyhounds, as depicted on the edge of an Assyrian bronze dish.

gratified and kept alive among those with slender means by the possibilities which the inexpensive Rabbit (*Lepus cuniculus*) offers. The use of the Ferret has already been indicated (see p. 369). Nor even here do we reach the lowest plane, for the Brown Rat (*Mus decumanus*) undoubtedly seems to minister in no small degree to the sporting instincts of a considerable fraction of the community, though it would not be admitted into an orthodox work on Sport.

BIRDS (AVES) HUNTED FOR SPORT

In the palmy days of falconry the Grey Heron (*Ardea cinerea*) was, of course, the chief bird pursued for sport, but hawking (for Rooks, Larks, &c.) is now practised by the few (see p. 369), having fallen from its once high estate owing to the introduction of and constant improvement in firearms. Among the numerous species which now fall victims to the art of the gunner the GAME-BIRDS (GALLINÆ) take first place, and of these, in this country, three are pre-eminent, *i.e.* Pheasant (*Phasianus Colchicus*), Red

Grouse (*Lagopus Scoticus*), and Partridge (*Perdix cinerea*). Other well-known members of the group are: Capercailzie (*Tetrao urogallus*), Black Grouse (*Lyrurus tetrix*), Ptarmigan (*Lagopus mutus*), and Quail (*Coturnix communis*).

In many kinds of shooting one is rather inclined to think that things are made too easy for the gunners, not all of whom can be called good shots, and the size of the "bag" too often appears to be the object of overmuch attention. It is clear that both these tendencies greatly diminish the true "sporting" element. The following quotations show that some sportsmen are inclined to compare our own methods unfavourably with those of "the good old days". Nicholas Everitt (in *The Sports of the World*) thus speaks on the point:—"In England, in the old days, our forbears were wont to sally forth in the early morning, before the autumnal dews had left the grass and undergrowth, accompanied by their favourite pointers, setters, or spaniels, to double the hedgerows and to hunt the commons and likely places for pheasants, when, if they obtained as many single birds as some of the modern school of sportsmen now require hundreds, they would return home contented with their bag and lot". The Marquess of Granby (in *English Sport*) speaks still more strongly:—"But, nevertheless, it is open to question whether there is as much real keenness about working for their sport amongst the younger generation of gunners as there used to be twenty or thirty years ago, let alone a century. A wild, rough day's shooting does not nowadays apparently appeal to many. The large majority of gunners would not say 'thank you' for the offer of such a day's sport. It would look as if the deliberately competitive system of shooting, which now so largely prevails- by which I mean that very often the owner of one shooting-place seems to vie with the next-door one as to the amount of game he can kill off his property, and appears seriously annoyed if he hears that anyone round about him has had an exceptionally heavy day's sport, or one better, as regards numbers, than any he can produce—has to a great extent unfamiliarized the rising and just risen race of sportsmen with those days when hard walking, and consequently good condition, coupled with some knowledge of wood and field craft, were necessary if any satisfactory results were to be obtained."

The Red Grouse (*Lagopus Scoticus*) is a game-bird of par-

RED GROUSE (*Lagopus Scoticus*) GLIDING UP TO THE GUNS

The Red Grouse or Muirfowl is here selected for illustration not only on account of its importance as a game bird, but also because it is the only member of its class peculiar to our islands In Great Britain it ranges from the Orkneys to Shropshire and Glamorgan, and is also found in Ireland, though less abundantly The Red Grouse is closely related to the Willow Grouse (*Lagopus albus*), which ranges right round the colder parts of the Northern Hemisphere, but it does not, like this species and the Ptarmigan (*L mutus*), turn white in winter, though there are seasonal changes in the plumage It is popularly supposed that the date at which grouse-shooting begins determines the rising of Parliament, and although the notion is erroneous its origin is not far to seek

RED GROUSE (LAGOPUS SCOTICUS) GLIDING UP TO THE GUNS

ticular interest, as it happens to be peculiar to Britain. The old method of "walking" has now mostly given place in this country to "driving". The latter practice, curiously enough, is more favourable to the maintenance of sufficient numbers on a grouse-moor than the former. It is suggested that when the birds are driven the old ones are the first to glide up to the guns, so that the undue destruction of immature individuals is obviated. Besides which the old birds are said to be so quarrelsome as seriously to interfere with the domestic plans of their juniors.

Fig. 1267.—Flamingoes (*Phœnicopterus roseus*)

PERCHING BIRDS (PASSERES).—Hawking for Rooks (*Corvus frugilegus*) and Sky-Larks (*Alauda arvensis*) has already been mentioned (see p. 369).

PLOVERS (LIMICOLÆ). — Woodcock (*Scolopax rusticola*) and Snipe (*Gallinago cœlestis*) are familiar sporting birds.

BUSTARDS (ALECTORIDES).—The Great Bustard (*Otis tarda*), once a native of Britain, affords good sport in several European countries, including Hungary, Russia, Roumania, Spain, and Portugal. The Little Bustard (*O. tetrax*) is also the object of sporting attentions.

DUCKS, GEESE, SWANS, AND FLAMINGOES (ANSERES).—The art of wild-fowling is largely applied to the members of this group (also to Woodcock and Snipe) on inland waters, in swampy districts, and along low shores. Our own Norfolk Broads furnish an example. In sport of the kind punting plays a large part.

The Flamingo (*Phœnicopterus roseus*, fig. 1267) is one of the most interesting birds that falls to the gun of the fowler in the Peninsula. Chapman & Buck (in *Wild Spain*) thus describe the method pursued: — "Flamingoes are always shy and watchful birds, and their great height gives them a commanding view of threatening dangers; but there are degrees in intensity of wildness, and despite the unquestionable difficulty of flamingo-shooting, we would certainly not place these long-necked birds in the first rank among impracticable wild-fowl. Wild geese, for example, many of the duck-tribe, and nearly all the larger raptores far exceed them in incessant vigilance and downright astuteness. Flamingoes, however, will not, as a rule, permit of approach by the ordinary Spanish method of the stalking-horse, or *cabresto*: while the treacherous pony is still two gunshots away, the warning croak of the sentries is given, and at once the whole herd start to walk away, opening out their ranks as they move off. The method we found most effective to secure them was by partially surrounding a herd with a line of mounted men, who rode far out beyond them and then drove them over our two guns, each concealed behind his horse and crouching knee-deep in water. Of all the dirty work that wild-fowling in its many forms necessitates, this flamingo-driving takes the palm. It is mud-larking pure and simple, man, horse, and gun alike encased in a clinging argillaceous covering like the street-Arab amphibians below London Bridge. It is a fine sight to see a big flight of flamingoes, say five hundred, coming well in to the gun—*entrando bien á la escopeta*! The whole sky is streaked with columns of strange forms, and the still air resounds with the babel of discordant croaks and cries. How wondrously they marshal those long uniform files, bird behind bird, without break or confusion, and how precisely do those thousand black wing-points beat in rapid regular unison! Flamingoes are not 'hard' birds: their feathers being loose and open, and the extremely long neck a specially vulnerable part, they may be brought down from a considerable height even with small shot."

REPTILES (Reptilia) HUNTED IN SPORT

About the only Reptile that can be considered as furnishing anything in the nature of sport is the American Alligator

(*Alligator Mississippiensis*), native to the south-eastern part of the United States. The "'Gator" is shot from the bank or from a boat, and is sometimes attracted by tying up a dog as a bait.

FISHES (PISCES) HUNTED IN SPORT

The "gentle craft" has always had, and always will have, a large number of supporters. It of course finds its highest expression in fly-fishing, as applied to species the capture of which

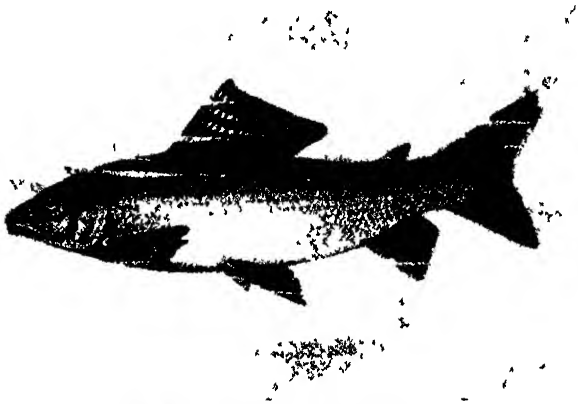


Fig 1268.—Grayling (*Thymallus vulgaris*)

calls for the exercise of patience, skill, and other sportsmanlike qualities.

Salmon (*Salmo salar*) and Trout (*S. fario*, &c.) are generally regarded as taking first rank among game-fishes, and the Grayling (*Thymallus vulgaris*, fig. 1268) may also be given an honourable place. H. A. Rolt's appreciation of the last-named fish (in *The Sports of the World*) is well worth quoting, especially as the pleasures of angling for Grayling are much less familiar than the joys of the fisher for salmon or trout:—"It is remarkable what a peculiar fascination there is in connection with the capture of the grayling with the artificial fly. Some men who have killed hundreds of trout fall hopelessly in love with the sport the 'gray lady of the stream' affords from the very first moment they enter the lists against it, and infinitely prefer the autumn and winter pastime it provides to any other branch of angling.

The enthusiasm and all-absorbing interest it evokes in the angler are incomprehensible even to many disciples of the good and observant Walton himself, for to sally forth, fly-rod in hand, when the ground is hard with frost or the fields are white with snow, seems to them to savour somewhat of folly and madness. In the soft, bright spring-time it is delightful to wander by the rippling stream and stalk the spotted trout, to the accompaniment of the glorious melody of birds—to watch the budding foliage bursting into new life, and gaze upon the river shining like gold

Fig 1269 — Pike (*Esox lucius*)

in the dancing sunlight. On quiet, restful summer evenings, too, the splash of the fish as they enjoy an abundant feast of Duns is the sweetest of music to the angler's ear, and he may perchance induce his quarry to look with favour upon the artifically-dressed copy of the fly he offers them, and grass a brace or two of lovely specimens ere darkness compels him, as a thorough sportsman, to leave the stream. But it is amid different and far less exhilarating surroundings that the grayling fisher's labours begin and are continued to the end. As autumn approaches, the rise of fly becomes sparse and erratic, and when September's days are out, the trout fisher finds his occupation gone. Thymallus steps in to fill what would otherwise be a great gap in his piscatorial life. But for the grayling, his rods would hang upon the wall during the long winter months,

'a mournful, half-accusing row', unused, and perhaps uncared for."

Some of the "coarse fish" also provide good sport, particularly the Pike (*Esox lucius*, fig. 1269), the Barbel (*Barbus vulgaris*), and the Perch (*Perca fluviatilis*).

Sea-fishing in many forms also has innumerable votaries. If size, strength, and game qualities are taken as the criteria, the great Tarpon (*Megalops thrissoides*), common off the coast of Florida, must be given a prominent position. It is to all intents and purposes a gigantic herring, which may be as much as five feet in length; and W. H. Grenfell says of it (in *The Sports of the World*) that ". . . until a new sporting fish is found I think the tarpon in the sea, as the salmon in fresh water, can still claim to be the most exciting quarry of the angler with the rod and line". Fishing for the Tunny (*Orcynus thynnus*) off the south coast of Spain would also seem to be a worthy occupation for the brethren of the rod, and specimens captured in this way have scaled as much as 50 pounds.

Among native marine fishes, the Grey Mullet (*Mugil capito*) and Bass (*Labrax lupus*) are perhaps the most esteemed, on account of their sporting qualities and the difficulties attending their capture. Both frequent estuaries, and the Bass is a near relative of the Perch

CHAPTER LXXIII

UTILITARIAN ZOOLOGY—ANIMAL PETS

It is the merest commonplace to say that a considerable number of animals are either domesticated or kept in captivity as pets, and those which have perhaps the best right to the name simply afford gratification to human tastes, or, it may be, serve as objects of affection. In the latter case the pet-keepers may either have a genuine liking for animals, or else the over-fed lap-dog, the spoilt feline, or the loquacious parrot may be the recipient of caresses that under different circumstances might have been bestowed upon some specimen or other of that alleged highest Mammal—*Homo sapiens.*

MAMMALS (MAMMALIA) AS PETS

MONKEYS (PRIMATES).—On account of their intelligence many species of Monkey find favour as pets among both civilized and uncivilized races. But most of them are so terribly mischievous that only a sailor or the late Frank Buckland could put up with their pranks for any lengthened period. It is said that even Buckland found his two favourites, "Tiny" and "The Hag", trying at times, and a friend recommended him to build a cage for himself in the middle of his study. It is interesting to note that the keepers in Zoological Gardens often make great pets of their charges, especially when these happen to be intelligent apes, as, *e.g.*, Chimpanzees (fig 1270).

The Marmosets are attractive little creatures, so far as appearance goes, and are not infrequently kept as pets; but they are rather lacking in intelligence, and apt to impose a tax on the olfactory organs.

FLESH-EATING MAMMALS (CARNIVORA).—The fact that this order includes both Dog and Cat makes it of primary importance from the present stand-point.

The Dog (*Canis familiaris*), man's earliest friend among the animals, is undoubtedly the "king of pets", for even the commonest mongrel is full of intelligence, and overflows with affection for his owner, even when subjected to much ill treatment, as is but too often the case. Among the breeds which have been brought into existence simply to be petted may be mentioned—the Italian Greyhound, the Pug (a diminutive and

Fig 1270.—Young Chimpanzee (*Anthropopithecus niger*)

particularly ugly relative of the mastiff, fig. 1271), the King Charles Spaniel, the Skye Terrier, the "Toy" Terrier, and the Poodle. The last is particularly clever in learning tricks, as may often be noted in exhibitions of performing dogs. The Dalmatian and the Hairless Dog of Japan are both curiosities in their way. No better example than these and other breeds of Dog could be given to show the effect of human interference upon the normal course of evolution. Modifications in shape, size, proportions, colour, hair, and even temperament have been brought about within a comparatively short space of time, in a

way that suggests nothing so much as "clay in the hands of the potter". By taking advantage of variations that occur naturally it is possible to "make to order" almost any desired pattern of the canine race.

The Cat (*Felis domesticus*).—The differences between the various breeds of this animal are by no means so striking as those existing between the different sorts of dog, and chiefly relate to colour, character of the fur, and relative length of the tail. It has been suggested that the stripes of the "tabby" indicate a strain derived from the ordinary Wild Cat (*Felis catus*) of Europe. Among both wild and tame animals it is not uncommon to find individuals in which pigment is either present in excess, or else largely deficient. Illustrations of this are afforded by "nigger" rabbits and white blackbirds. Such "sports" are respectively described in technical language as examples of "melanism" and "albinism". The jet black cat once associated with magical practices, and the pure white pussy with blue eyes are thus classed. Why albino cats should be usually deaf, as appears to be the case, is as yet unexplained. The long and handsome coats of the Persian or Angora Cats (fig. 1272) renders them great favourites among those who admire felines, though they seem rather apt to be short-tempered, if one may be permitted to say so.

Fig 1271.—Pug Dog

That the indigenous cats of the Isle of Man are devoid of tails is known to all; some of the Crimean cats are said to be similarly deficient, and the same peculiarity has been noticed in some Japanese individuals. Lydekker (in *The Royal Natural History*) thus speaks of some other peculiar varieties:—"In Siam there is a breed of cats reserved for royalty, characterized by

their uniform, and often dark, fawn colour, their blue eyes, and the presence of two or more perfectly bald spots on the forehead. Siam, together with Burma, also possesses a breed known as the Malay cat, in which the tail is but of half the usual length, and is often, through deformity in its bones, tightly curled up into a knot."

The present writer is not a great lover of cats, but, desiring to be just, adds the following appreciation by Romanes (in *Animal Intelligence*) of this domestic carnivore:—"The cat is unquestionably a highly intelligent animal, though, when contrasted

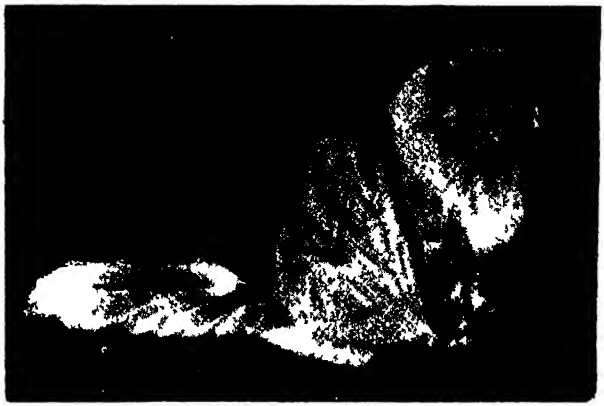


Fig. 1272.—Persian Cat

with its great domestic rival the dog, its intelligence, from being cast in quite a different mould, is very frequently underrated. Comparatively unsocial in temperament, wanderingly predaceous in habits, and lacking in the affectionate docility of the canine nature, this animal has never in any considerable degree been subject to the psychological transforming influences whereby a prolonged and intimate association with man has so profoundly modified the psychology of the dog. Nevertheless, the cat is not only by nature an animal remarkable for intelligence, but, in spite of its naturally imposed disadvantage of temperament, has not altogether escaped those privileges of nurture which unnumbered centuries of domestication could scarcely fail to supply. Thus, as contrasted with most of the wild species of the genus when tamed from their youngest days, the domestic cat is conspicuously of less uncertain temper towards its masters

—the uncertainty of temper displayed by nearly all the wild members of the feline tribe when tamed being, of course, an expression of the interference of individual with hereditary experience. And, as contrasted with all the wild species of the genus when tamed, the domestic cat is conspicuous in alone manifesting any exalted development of affection towards the human kind; for in many individual cases such affection, under favouring circumstances, reaches a level fully comparable to that which it attains in the dog."

Passing notice may be given to the Mangoustis or Mungooses, also known as Ichneumons, of which one, the Egyptian Mungoose

Fig. 1273. Indian Mungoose *Herpestes griseus*

(*Herpestes ichneumon*), has been domesticated in Egypt from time immemorial, while the common Indian Mungoose (*H. griseus*, fig. 1273) is commonly kept as a pet in its native country, and appears to be both intelligent and affectionate. The latter species is known to the readers of Kipling as "Rikki-tikki".

GNAWING MAMMALS (RODENTIA).—Human influence has resulted in the production of a large number of varieties of Rabbits, Rats, and Mice, some of which have been alternately tended and neglected by almost every boy. Upon the Rabbit (*Lepus cuniculus*) one of the most remarkable results of domestication has been, in certain breeds, the great elongation of the ears, and the drooping position they have assumed. There has also been a large amount of variation in the colour and character of the fur.

The various domesticated breeds of Rat (*Mus rattus*) and

Mouse (*M. musculus*) differ chiefly from one another in colour. The curious evolutions of "waltzing mice" appear to be due to defects in the structure of the internal ear.

Among other rodents serving as pets may be mentioned—the Alpine Marmot (*Arctomys marmotta*), the Dormouse (*Muscardinus avellanarius*), the Squirrel (*Sciurus vulgaris*), and the Guinea-Pig.

BIRDS (AVES) AS PETS

The number of species represented among pet-birds, including those which are better described as "captives", is very large indeed, and it will be unnecessary to mention more than a few of them.

PERCHING BIRDS (PASSERES).—Many of these are domesticated on account of their beauty or vocal powers, or both, and not a few of these have exchanged the sweets of liberty for a small and uncomfortable cage. To treat small birds in this fashion is scarcely less than criminal. Large aviaries, of course, are on a somewhat different footing. Fortunately the objection does not apply to the most popular of all pet birds, the Canary (*Serinus canarius*, fig. 1274), of which countless generations have been brought up in captivity, and of which the numerous strikingly different breeds may almost be regarded as artificial products. Newton makes the following remarks about this bird (in *A Dictionary of Birds*):—"It abounds not only in the islands whence it has its name, but in the neighbouring groups of the Madeiras and Azores. It seems to have been imported into Europe very early in the sixteenth century. Turner in 1544 speaks of the birds '*quas Anglia aues canarias uocat*', a statement confirmed by the poet Gascoigne, who died in 1577, and speaks . . . of 'Canara byrds'. Gesner had not seen one in 1555, but he gave an account of it . . . , communicated to him by Raphael Seiler of Augsburg under the name of *Suckervögele*. The wild stock is of an olive-green, mottled with dark-brown above and greenish-yellow beneath. All the bright-hued examples we now see in captivity have been induced by carefully breeding from any chance varieties that have shown themselves; and not only the colour but the build and stature of the bird have in this manner been greatly modified. The change must have begun early, for Hernandez, who died in 1587, described the bird . . . as being

wholly yellow (*tota lutea*), except the end of its wings. Of late the ingenuity of 'the fancy', which might seem to have exhausted itself in the production of top-knots, feathered feet, and so forth, has brought about a still further change from the original type. It has been found by a particular treatment, in which the mixing

Fig. 1274.—Canaries (*Serinus canarius*). 1, Wild form. 2, common yellow. 3, crested variety. 4, Scotch fancy.

of large quantities of cayenne-pepper with the food plays an important part, the ordinary 'canary yellow' may be intensified so as to verge upon a more or less brilliant flame colour. Birds which have successfully undergone this forcing process, and are hence called 'hot canaries', command a very high price, for a large proportion die under the discipline, though it is said that

they soon become exceedingly fond of the exciting condiment." Space forbids any attempt to describe the methods by which the German fanciers of the Harz valleys teach canaries the notes of other birds, or even various tunes.

Another well-known and extremely pretty cage-bird is the Java Sparrow (*Munia oryzivora*), which has long been an object of domestication, and is distinguished by its extreme tameness.

On account of their intelligence, sprightliness, and imitative powers, the Raven, Jackdaw, Magpie, and Starling appeal to many persons more than Canaries and other small singing-birds. They are not, however, so frequently seen in captivity, partly on account of the thievish propensities of all but the last.

PARROTS (PSITTACI).—Among the many species of this group which are kept in captivity, the common Grey Parrot (*Psittacus erithacus*), native to tropical Africa, probably stands highest in public estimation. This is partly due to its extreme liveliness, but chiefly on account of the clever way in which it learns fragments of human speech, and imitates familiar sounds, such as the drawing of corks and the like. The often singularly malapropos nature of the remarks and sounds greatly increase their charm.

Parrots have been known and appreciated for more than two thousand years as clever imitative birds, often with brilliant plumage. Some of the Indian species appear to have been those first known to Europeans, while the resources of Africa were exploited later on. Regarding this, Newton (in *A Dictionary of Birds*) speaks as follows:—"That Africa had parrots does not seem to have been discovered by the ancients till long after, as Pliny tells us (vi, 29) that they were first met with by explorers employed by Nero beyond the limits of Upper Egypt. These birds, highly prized from the first, reprobated by the moralist, and celebrated by more than one classical poet, as time went on were brought in great numbers to Rome, and ministered in various ways to the luxury of the age. Not only were they lodged in cages of tortoise-shell and ivory, with silver wires, but they were professedly esteemed as delicacies for the table, and one emperor is said to have fed his lions upon them. . . . With the decline of the Roman Empire the demand for parrots in Europe lessened, and so the supply dwindled, yet all knowledge of them was not wholly lost, and they are occasionally mentioned by one writer or another until in the fifteenth century began that

career of geographical discovery which has since proceeded uninterruptedly This immediately brought with it the knowledge of many more forms of these birds than had ever before been seen, for whatever races of men were visited by European navigators—whether in the East Indies or the West, whether in Africa or the islands of the Pacific—it was almost invariably found that even the most savage tribes had tamed some kind

Fig 1275 Macaw (*Ara*)

of parrot, and, moreover, experience soon showed that no bird was more easily kept alive on board ship and brought home, while, if it had not the merit of 'speech', it was almost certain to be of beautiful plumage."

One of the prettiest pets among these birds is the Grass-Parakeet or Budgerigar (*Melopsittacus undulatus*) of Australia. Yellow, green, and black are the chief components of the colour scheme, but the two central tail-quills are blue, and there is a patch of the same hue on either side of the face.

The affectionate little Love-Birds are deservedly popular.

The name is properly applied to certain African species (of *Agapornis*), but it may also be taken to include the Parrotlets (*Psittacula*) of South America.

The sprightly crested Cockatoos (*Cacatuidæ*) of the Australian region do not lack their admirers, while for gaudy coloration few birds surpass the long-tailed Macaws (species of *Ara*, fig. 1275), which range from Mexico into South America.

REPTILES (REPTILIA) AS PETS

Reptiles make no appeal to the affections or fancies of most persons, though various species prove attractive to some. The ancient Egyptians, as everyone knows, regarded the Nile Crocodile (*Crocodilus Niloticus*) as sacred, and made a sort of pet divinity of the creature, but this hardly comes within the scope of the present section. Some persons have a fancy for certain Snakes, such as our common and innocuous Grass-Snake (*Tropidonotus natrix*), and the Indian snake-charmers tame the Cobra (*Naia tripudians*), actuated, however, by strictly business motives. Regarding the latter, Gadow (in *The Cambridge Natural History*) speaks as follows:—"This cobra is used by Indian conjurers. The 'dance' is the habit of these snakes of erecting themselves, when agitated, upon the hinder third or quarter of their length, whilst they spread out the hood and sway the head and neck to the right and left, always in an attitude ready for striking. They are docile, and by nature not vicious. Most of the performing cobras have their teeth drawn, and they then know well that they cannot bite. They only strike at the hand, just as uninjured specimens soon avoid biting into the iron rod with which they are lifted up in menageries. The drawing of the teeth is an operation which has to be repeated, since reserve-teeth soon take the place of the lost pair."

Various Lizards are or have been tamed, and some of them are very attractive, *e.g.* the beautiful Green Lizard (*Lacerta viridis*). The Common Gecko (*Tarentola Mauritanica*) of North Africa and South Spain and Portugal often lives in houses in a half-domesticated condition, running over the walls and ceilings in pursuit of flies. And such lizards are sometimes actually tamed.

The most familiar domesticated reptile in this country is the Grecian Tortoise (*Testudo Græca*), though it can scarcely be

called an interesting pet. Gilbert White has immortalized one specimen, which was over forty years old when it came into his possession in 1780, and died fourteen years later. But, for longevity, it would be hard to beat some of the huge land-tortoises which were at one time common in the islands of the Indian Ocean. Regarding one species (*Testudo Sumeirei*) Gadow makes the following interesting remarks (in *The Cambridge Natural History*):—"This kind is supposed to have been the species peculiar to the Seychelles. In 1766 five large tortoises were brought from the Seychelles to Mauritius by Chevalier Marion de Tresne. Of these only three were alive in 1898, two in Mauritius and one in London; the latter specimen soon died in the Zoological Gardens. One of the two survivors, the last of their race, is famous. It was kept at Port Louis, and when Mauritius became a British possession in 1810 the tortoise was especially mentioned and taken over. It still [1900] lives there in the grounds of the barracks of the garrison. According to the proverbial oldest inhabitants, it had in 1810 already reached its present size, namely, a shell-length of about 40 inches, with a greatest circumference of . . . 8 feet 6 inches. When walking it stands about . . . 25.4 inches high, . . . and it can then carry with ease two full-grown men on its back. This old male is now nearly blind, but is otherwise of regular habits and in good health. Although it has been known for nearly 150 years, it had to wait for its scientific name until the year 1892."

AMPHIBIANS (AMPHIBIA) AS PETS

Ordinary Toads and Frogs have at times been subjected to domestication, and are by no means wanting in interest and intelligence The pretty little Green Tree-Frogs of Europe (*Hyla arborea*) are less known as pets than they deserve to be. In North and Central America the Horned Toad (*Phrynosoma*) is subjected to a certain amount of domestication.

FISHES (PISCES) AS PETS

The greatest favourite in the aquarium is probably the Gold-Fish (*Carassius auratus*, fig. 1276), a kind of carp native to China and Japan. Domestication has eliminated dark pigment from its

skin, leaving only the golden-yellow hue from which its name is derived. Various monstrosities have also been produced, especially the "Telescope Fish", with eyes on short projections, and a large abnormal tail-fin. It is stated that the Gold-Fish was originally introduced into this country in 1691

Another aquarium favourite is the Paradise-Fish (*Polyacanthus viridi-auratus*, fig. 1276), domesticated in China from very remote

Fig 1276.—Pet Fishes. 1, Gold Fish ***Carassius auratus*** **2 Telescope variety of same 3, Paradise Fish (*Polyacanthus viridi-auratus*)**

times, and only known in captivity. Its golden sides are cross-barred with red, and some of its fins are abnormally developed (see also vol. iii, p 427)

The Siamese keep certain pugnacious fishes in captivity in order to enjoy the sight of their combats.

INSECTS (INSECTA) AS PETS

Some Insects are excitable, and can easily be induced to fight together. The ingenious Chinese keep various species in captivity in order to enjoy these mimic combats. Their list includes Mantids, Beetles, Grasshoppers, and Crickets The same curious kind of amusement is practised to some extent in Italy. Nor must the evolutions of performing Fleas be forgotten.

CHAPTER LXXIV

UTILITARIAN ZOOLOGY—ANIMAL PRODUCTS USED FOR DECORATIVE PURPOSES—ANIMAL ÆSTHETICS

We have here first to consider the chief animal products employed for decorative purposes, and afterwards briefly to review the principles of Animal Æsthetics.

ANIMAL PRODUCTS USED FOR DECORATIVE PURPOSES

A number of animal products which were originally valued by mankind chiefly as ministering to the primary necessities of life, now derive their main worth from the ornamental or decorative possibilities they present, or they are, at any rate, in increased demand on that account. Furs, horns, silk, and the skins of some birds belong to this category (see pp. 303, 310, 259, and 308).

We are especially concerned in this chapter with products which from the first have been employed by way of ornament or decoration, sometimes also as a means of heightening the attractions of materials of other kind.

Decorative Products of Mammals (Mammalia).—Some Mammals have been ruthlessly hunted down by man for the sake of the ivory furnished by their teeth. Prominent among these are the Elephants (*Elephas*), and, as will be gathered from fig. 1277, the tusks of the African species may attain very large dimensions. The extinct Mammoth (*E. primigenius*) has also long been known as a source of "fossil ivory". The tusks of Walrus (*Trichechus rosmarus*) furnish a further supply, as does the long spirally-grooved "horn" of the male Narwhal (*Monodon monoceros*), of which two are occasionally present in the same animal. While the tusks of the Walrus are canine teeth, those of the other animals mentioned are incisors.

Many of the trophies of sport are decidedly ornamental, such as the skins of beasts of prey, the antlers of deer, the heads of fox or wolf, the prepared feet of the elephant, &c. &c. Among primitive races such things as necklaces of tigers' or lions' claws are greatly esteemed.

Decorative Products of Birds (Aves).—The beautiful plumage of many birds seems always to have appealed to the human colour-sense or appreciation of form, and much slaughter of certain members of the feathered race has resulted on the part of savage races, often to minister to the vanity of other races sometimes supposed to be fully civilized. The trade in ostrich-feathers (see p. 251) is a legitimate branch of the plume-industry, and nothing can be said against the use of the cast feathers of beautiful forms like the different species of Peacock. But, on the other hand, the wholesale massacre that takes place every year of many exquisitely lovely species, purely to satisfy the love of finery which has been inherited by civilized nations from barbarian ancestors, deserves the most unsparing censure. Birds of Paradise, Sun-Birds, Humming-Birds, and Egrets are prominent in the long list of victims.

Fig 1277 — Tusks of African Elephant

Decorative Products of Reptiles (Reptilia).—The skins of Crocodiles and various lizards are used for ornamental purposes, but the most important reptilian product is tortoise-shell, which consists of the horny epidermic shields of the widely-distributed Hawksbill Turtle (*Chelone imbricata*, fig. 1278). When softened

by heat these can be worked up into all sorts of artistic objects. Very undesirable practices are often resorted to in procuring the raw material, as will be seen from the following quotation from Tennent (in *The Natural History of Ceylon*).—"If taken from the animal after death and decomposition, the colour of the shell becomes clouded and milky, and hence the cruel expedient is resorted to of seizing the turtles as they repair to the shore to deposit their eggs, and suspending them over fires till heat

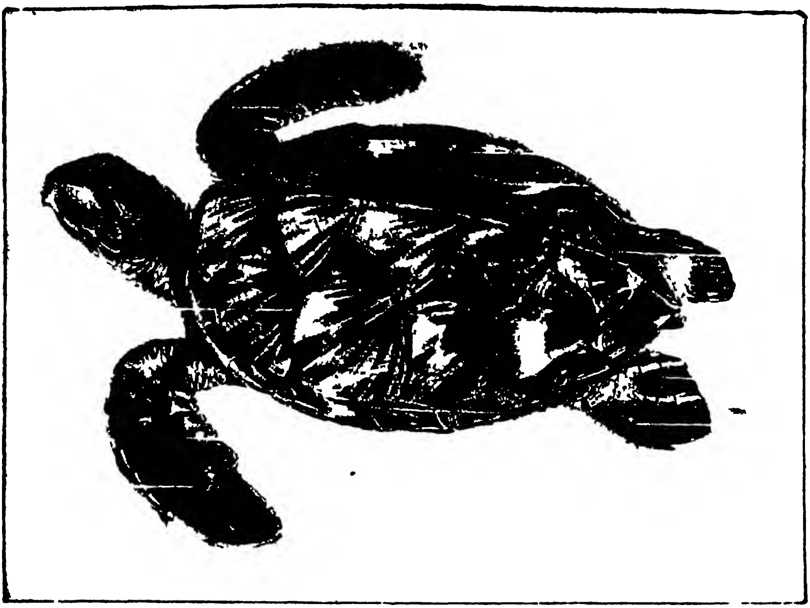


Fig 178 Hawksbill Turtle (*Chelone imbricata*)

makes the plates on the dorsal shields start from the bone of the carapace, after which the creature is permitted to escape to the water. At Celebes, where the finest tortoise-shell is exported to China, the natives kill the turtles by blows on the head, and immerse the shell in boiling water to detach the shields. Dry heat is only resorted to by the unskilful, who frequently destroy the tortoise-shell in the operation."

DECORATIVE PRODUCTS OF FISHES (PISCES).—Ornamental leather is made from the skins of Dog-Fishes and Sharks (shagreen), while the scales of Dace (*Leuciscus vulgaris*) and

Bleak (*L. alburnus*) are employed in the manufacture of artificial pearls.

DECORATIVE PRODUCTS OF MOLLUSCS (MOLLUSCA). — The shells of the Pearly Nautilus, of many univalves, and numerous bivalves, are largely used for purposes of personal decoration by savage races, and to some extent by civilized ones. Some of them are worked up into ornamental knick-knacks even in British watering - places, while the Chinese are singularly skilful in the construction of the images of gods, human beings, animals, and plants, from a variety of small shells (fig. 1279).

Fig. 1279 – Chinese Shell ornament

Sea-Snails (*Gastropoda*).

The thick shells of some Sea-Snails (species of *Cassis*, &c.) are made up of layers of different tints, which has rendered them a favourite material upon which to carve cameos (fig. 1280). Pink pearls are the pathological products of certain species, especially the large Conch - Shell (*Strombus gigas*) of the West Indies.

The most famous product of Sea-Snails was, however, the royal dye

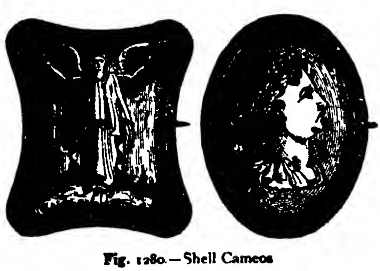


Fig. 1280.—Shell Cameos

Fig 1281.—Murex Bronderi

known as Tyrian Purple, prepared by the ancient Phœnicians from species of Purpura and Murex (fig. 1281). It is secreted by a gland in the gill-cavity, closely connected with the intestine.

The explorations of the Phœnicians westward, which had no small influence upon the course of history, were partly conducted with the object of securing larger supplies of these molluscs.

Some of the travellers of the seventeenth and eighteenth centuries state that the natives of Ecuador and Costa Rica obtained a purple fluid from a species of Purpura, and used it to dye cotton. A kind of Sea-Slug (*Aplysia camelus*) is still used by the Portuguese for a similar purpose.

Bivalve Mollusca (*Lamellibranchia*).—Pearls and mother-of-pearl are chiefly derived from members of this group. Mother-of-pearl or nacre is the iridescent internal layer of the shell,

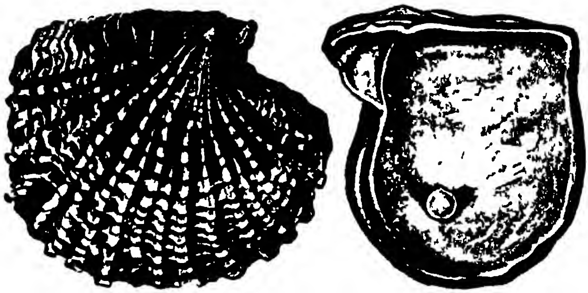


Fig. 128a.—Shells of Pearl Oyster (*Margaritifera vulgaris*) and pearl of same

while pearls consist of layers of similar material deposited round various foreign bodies which, in the most valuable kinds, are stages in the development of parasitic forms (see p. 204). The most important pearl-fisheries are those of the Red Sea, India, Ceylon, Queensland, some of the South Pacific archipelagoes, lower California, and the Pacific coast of Central America. The bivalve of greatest economic value in this connection is the Pearl-Oyster (*Margaritifera vulgaris*), which in reality is more of a mussel than an oyster, but belongs to a different family from either (*Aviculidæ*). The once important pearl-fisheries of Ceylon, after a record yield in 1891, benefiting the revenue of the island to the extent of hard on a million rupees, completely failed for an entire decade. As the outcome of this the pearl-oyster question has recently been investigated by Professor Herdman, assisted by Mr. James Hornell. These two experts have fully worked out the life-history of the tape-worm which leads to the formation of "orient pearls", and it is hoped that

the knowledge acquired will form the basis of measures by which the industry may be resuscitated. The first part of Herdman's *Report on the Pearl-Oyster Fisheries of the Gulf of Manaar* includes a very interesting historical sketch from which the following extract is taken:—"The pearl-fisheries of Ceylon, India, and the Persian Gulf, yielding the highly prized 'Oriental' pearl, are of very great antiquity. They are probably the most ancient fisheries still in existence, and seem to be carried on at the present day under very much the same conditions as 2000 or perhaps even 3000 years ago. These fisheries are referred to by various classical writers, and Pliny, after saying how highly valued the pearls are at Rome, refers to Taprobane [Ceylon] as 'the most productive of pearls of all parts of the world'. . . . But the Singhalese records take us to still earlier times. According to the 'Mahawanso', pearls figure in the list of native products sent as a present from King Vijáya of Ceylon to his Indian father-in-law in about 540–550 B.C.; and again when, in B.C. 306, King Devanampiyatissa sent an embassy to India the presents are said to include eight kinds of Ceylon pearls. The King's Hall in the Brazen Palace at Anuradhapura (B.C. 161) is said to have been decorated with native pearls. The mortar in the ruins of Polonaruwa shows the remains of the pearl-oyster shells which were used in its manufacture—no doubt the refuse of an early fishery. Many other references could be given. In the eighth to eleventh centuries, trade in the East was in the hands of the Persians and Arabs, and we find Arab writers alluding to the pearls. We know also that they enriched the kings of Ceylon in the days of Marco Polo (1291). One record, given by Friar Jordanus, says that in 1330 about 8000 boats were engaged in the pearl-fisheries of the Gulf of Manaar."

From the remote times mentioned in the above extract down to the present day the pearl-oysters have been collected by native divers, but it is not improbable that dredging will ultimately be the chief method employed.

Pearls are formed within a number of bivalves besides the one mentioned, nor are all of these marine, for the once famous British pearls were obtained from Fresh water Mussels. Purple pearls are formed within some of the Ark-Shells (*Arca*).

Decorative Products of Insects (Insecta).—There is not much to mention with regard to this group of animals. The

hard metallic-looking wing-covers or elytra of certain Beetles serve for various decorative purposes, and some of the more beautiful Butterflies are sometimes placed in glass cases and used as ornaments. Some of the Scale-Insects (*Coccidæ*) are the source of economic products of some importance in the present connection, *e.g.* the Cochineal Insect (*Coccus cacti*) furnishes red pigment (see p. 260). Objects known as "ground pearls" are found in the earth in various parts of the world, *e.g.* in the island of St. Vincent (West Indies), where they are made into necklaces, &c. They are in reality the encysted pupæ of Scale-Insects, covered by a hard substance looking like pearl or glass. The West Indian ones mentioned above belong to a species of Margarodes.

ANIMAL ÆSTHETICS

The course of human evolution has necessarily involved a gradually improving adaptation to surroundings, of which the outcome is seen in all the intricate details of modern civilization. Imaginative literature and the various branches of art are among the most remarkable results of this evolution, and the full discussion of their nature and origin is the province of that branch of philosophy known as Æsthetic. But as, after all, man is an animal, who has always lived among other animals that have profoundly influenced the course of his mental development, it naturally follows that the study of Æsthetic, as indeed of all other departments of philosophy, must look for its foundations among the principles of biology. The interdependence of natural science and philosophy is well brought out in the following quotation from Karl Groos (in *The Play of Animals*):—"Man's animal nature reveals itself in instinctive acts, and the latest investigators tell us that man has at least as many instincts as the brutes have, though most of them have become unrecognizable through the influence of education and tradition. Therefore an accurate knowledge of the animal world, where pure instinct is displayed, is indispensable in weighing the importance of inherited impulses in men. . . . The animal psychologist must harbour in his breast not only two souls, but more; he must unite with a thorough training in physiology, psychology, and biology the experience of a traveller, the practical knowledge of

the director of a zoological garden, and the outdoor lore of a forester. And even then he could not round up his labours satisfactorily unless he were familiar with the trend of modern æsthetics." To briefly indicate some of the chief points of contact between Biology and Æsthetics is all that can be attempted here, and those who wish to pursue the subject fully are referred to the works of Herbert Spencer, Bain, Baldwin, Romanes, and Lloyd Morgan, as also to Grant Allen's *Physiological Æsthetics*, Knight's *Philosophy of the Beautiful*, Bosanquet's *History of Æsthetic*, and Groos's *Play of Animals*.

No human being or highly-organized animal would be able to live for any length of time, nor would the preservation of its species be possible, if constant adjustment to the surroundings was not brought about by the agency of the nervous system and sense-organs (see p. 2). This is seen, for example, in the utilitarian significance of pleasure and pain. Pleasure, broadly speaking, promotes actions which conduce to self-preservation and the maintenance of the species, while pain as constantly forbids other actions which would mean self-destruction. Unless pleasure were associated, for instance, with the act of eating, an animal would probably be content to starve, while if contact with burning substances caused no pain it would be very liable to self-cremation. Now there can be no doubt at all that the feelings to which Beauty and Ugliness give rise are simply to be regarded as finer manifestations of pleasure and pain, and since Æsthetics is concerned with such feelings it clearly rests upon a physiological basis.

THE SENSE OF SIGHT AND ITS BEARING ON ÆSTHETICS.—We have only to reflect for a moment on the deprivations suffered by a man blind from birth to realize that artistic enjoyment depends most upon the sense of sight. And our criteria of what is beautiful in colour, form, and movement have largely been evolved with reference to the animal world, including human beings. To mention examples is unnecessary, for the illustration scheme of this work provides them in abundance. But a few generalities are perhaps desirable.

No one will deny that the human colour-sense has been largely educated by the materials which flowers provide. But the exquisite tints and colour-schemes of the floral world are strictly utilitarian with reference to plants themselves, being

simply devices for attracting beneficial insects (see p. 85). To insects, therefore, our æsthetic debt is very large.

The Courtship Colours of Insects, Birds, and some other animals (see p. 143) are also as a rule beautiful to us, and have played no small part in the evolution of our artistic sense. With reference to the animals which display them it is pretty certain that they are purely utilitarian.

Were we similarly to consider the materials upon which our ideas of the beautiful in form and movement are based, we should once more have to acknowledge that the evolution of the æsthetic sense has largely progressed on lines determined by the animal world.

Ugliness in the first instance appears to have been associated with what was harmful or dangerous. The repugnance which most of us feel towards snakes, scorpions, and centipedes is probably part of the legacy which has been handed down to us by our prehistoric ancestors (see vol. iii, p. 370). It is also generally admitted that "warning coloration", which marks undesirable properties in many animals, is crude and inartistic from the human stand-point.

The Sense of Hearing and its Bearing on Æsthetics.—Next to sight, hearing is the most important sense, from the æsthetic stand-point. The song of birds and the chirp of insects, which further the courtships of their owners (and hence are of utilitarian nature), must have had something to do with the evolution of our standards of what is beautiful in the realm of sound.

The Sense of Smell and its Bearing on Æsthetics.—That certain odours are, to our thinking, of fragrant nature, is largely due to the direct or indirect influence which animals have had upon human development. Many species emit strong musky odours, serving for purposes of recognition, and also as courtship accessories. Civet-cats are an example of this, and at one time "civet", obtained from certain glands in these animals, was a favourite perfume, though it would now be considered rank. It has been replaced by musk, obtained from glands possessed by the Musk Deer (*Moschus moschiferus*), though even this perfume is too coarse for cultivated tastes, which show a preference for floral odours. But, as we have elsewhere seen (see p. 85), the delicate scents of flowers are of utilitarian mean-

ing to the plants which possess them, being so many baits to attract useful insects.

One substance used as a sort of basis in the manufacture of perfume, *i.e.* ambergris, is on an entirely different footing from such things as musk or attar of roses, its properties being, so to speak, accidental. It consists of concretions, which are formed in the intestine of the Sperm-Whale as a result of disease.

THE SENSE OF TASTE AND ITS BEARING ON ÆSTHETICS.—The organs of taste were, in the first instance, undoubtedly evolved in relation to food-testing, a purely utilitarian matter. Adaptation to diets of particular kind would have been difficult, if not impossible, without this, and there would also have been a liability to take in poisonous substances. Pleasurable sensations would gradually come to be associated with the taste of desirable food, and sensations of opposite kind with that of unsuitable aliment, to say nothing of poisons.

Tastes pure and simple, such as that of sweetness, do not rank very high in the æsthetic scale, but it is otherwise with "flavours", which are combinations of tastes and odours. The triumphs of the art of cookery, so dear to the gourmand, are of necessity largely based on the properties of animals in the dead state. But this of course is a mere commonplace.

THE EVOLUTION OF ART AND CERTAIN FORMS OF LITERATURE.—In the evolution of Æsthetics, Groos considers that "play" has been a dominant factor. By Spencer (and Schiller before him) play was regarded as a manifestation of surplus energy, an expression of the "joy of life". But Groos interprets the play of animals as being an instinct whereby preparation is given for the stern realities of existence. A kitten, for example, by playing with various objects, including its own tail, acquires fitness for the pursuit of mice. According to this view an animal or young child does not play because it is young, but has a period of youth in order that it may play. Imitation is here of importance in helping the acquisition of powers that will later on be useful. Baldwin regards it as standing between instinct and intelligence, sometimes promoting the preservation of the former, and in other cases enabling it to be more or less discarded in favour of intelligent actions. Groos summarizes his ideas regarding the relation between play and art in the following table, which, though susceptible of criticism, will serve as the basis for a few remarks.

PLAY

Experimentation

(Joy in being able)

(Pretence: conscious self-deception)

Self-exhibition.	Imitation.	Decoration.
The Personal With animals { Courtship arts. With man { Dance with excitement. Music. Lyric poetry.	The True Imitative arts. Imitative dance. Pantomime. Sculpture. Painting. Epic Poetry. Drama.	The Beautiful Building arts. Ornamentation. Architecture.

Plenty of examples of each of the three primary groups above are to be found in the animal world. *Self-exhibition* as manifested in Courtship arts is sufficiently illustrated by Birds and Spiders, and some account of it has already been given (see pp. 148 and 166).

No better instance of *Imitation* could possibly be given than the concerted Dances of some birds, graphically described by Hudson (in *The Naturalist in La Plata*). The following is his account of the evolutions of the Spur-winged Lapwing (*Hoplopterus cayanus*, fig. 1283) of South America:—"The lapwing display, called by the natives its 'dance', or 'serious dance'—by which they mean square dance—requires three birds for its performance, and is, so far as I know, unique in this respect. The birds are so fond of it that they indulge in it all the year round, and at frequent intervals during the day, also on moonlight nights. If a person watches any two birds for some time—for they live in pairs—he will see another lapwing, one of a neighbouring couple, rise up and fly to them, leaving his own mate to guard their chosen ground; and instead of resenting this visit as an unwarranted intrusion on their domain, as they would certainly resent the approach of almost any other bird, they welcome it with notes and signs of pleasure. Advancing to the visitor, they place themselves behind it; then all three, keeping step, begin a rapid march, uttering resonant drumming notes in time with their movements; the notes of the pair behind

being emitted in a stream, like a drum-roll, while the leader utters loud single notes at regular intervals. The march ceases; the leader elevates his wings and stands erect and motionless, still uttering loud notes; while the other two, with puffed-out plumage and standing exactly abreast, stoop forward and downward until the tips of their beaks touch the ground, and, sinking their rhythmical voices to a murmur, remain for some time in this posture. The performance is then over, and the visitor

Fig 1283 —Dance of Spur-winged Lapwings (*Hoplopterus cayanus*)

goes back to his own ground and mate, to receive a visitor himself later on."

As to the third kind of artistic development, placed under the head of *Decoration*, we once more find among Birds the best illustrations. Their nests not only exemplify, in some cases, the art of building carried to a high pitch of perfection, but may also involve a certain amount of decorative skill. Both, however, are most strikingly seen in the curious "runs" made by the Bower-Birds, native to the Australian region. They appear to play some part in courtship, and their original discoverer, Gould, describes them as follows (in *Proceedings Zool. Society*, 1840):—"These constructions are perfectly anomalous in the architecture of birds, and consist in a collection of pieces of stick or grass, formed into a bower; or one of them (that

of the *Chlamydera*) might be called an avenue, being about 3 feet in length, and 7 or 8 inches broad inside; a transverse section giving the figure of a horse-shoe, the round part downwards. They are used by the birds as a playing-house, or 'run' as it is termed, and are used by the males to attract the females. The 'run' of the Satin-Bird is much smaller, being less than 1 foot in length, and moreover differs from that just described in being decorated with the highly-coloured feathers of the parrot tribe, the *Chlamydera*, on the other hand, collects around its

Fig. 1284.—Gardener Birds (*Amblyornis inornatus*), with hut and garden, male in foreground, female at back

'run' a quantity of stones, shells, bleached bones, &c.; they are also strewed down the centre within."

Newton thus describes (in *A Dictionary of Birds*) some even more remarkable kinds of Bower-Bird, unknown to science at the time of Gould's observations:—"A bird of New Guinea, . . . *Amblyornis inornatus*, fig. 1284, has been found by Signor Beccari to present not only a modification of bower-building, but an appreciation of beauty perhaps unparalleled in the animal world. His interesting observations . . . show that this species, which he not inaptly calls the 'Gardener' (*Gjardiniere*), builds at the foot of a small tree a kind of hut or cabin (*capanna*) some 2 feet in height, roofed with orchid-stems that slope to the ground, regularly radiating from the central support, which is covered

with a conical mass of moss, and sheltering a gallery round it. One side of this hut is left open, and in front of it is arranged a bed of verdant moss, bedecked with blossoms and berries of the brightest colours. As these ornaments wither they are removed to a heap behind the hut, and replaced by others that are fresh. The hut is circular and some 3 feet in diameter, and the mossy lawn in front of it nearly twice that expanse. Each hut and garden are, it is believed, though not known, the work of a single pair of birds, or perhaps of the male only; and it may be observed that this species, as its trivial name implies, is wholly inornate in plumage. Not less remarkable is the more recently described 'bower' of *Prionodura*, a genus of which the male . . . is conspicuous for his bright orange coloration. This structure is said by Mr. Devis . . . to be piled up almost horizontally round the base of a tree to the height of from 4 to 6 feet, and around it are a number of hut-like fabrics, having the look of a dwarfed native camp."

With the stages in the evolution of human art we are here not directly concerned, but enough has been said to show that a careful study of the habits of animals is likely to throw a good deal of light upon the subject.

Animals as Material for Art and Literature.—Animals form such an important part of the environment of man that they naturally figure largely in art and literature. If, in imagination, we entirely eliminate animal forms from galleries of sculpture or pictures we shall realize this very fully, and ideas derived from the animal world are also embodied to some extent in music. As we have elsewhere seen (p. 341), the Tarantella originated with reference to a kind of spider.

The art of decoration is also indebted to the animal world, some of the most beautiful designs being based upon animal forms. Mr. Talwin Morris' "peacock design" on the covers of this book is a particularly charming example.

In literature our debt to animals is no less great. The very letters of the alphabet, which, as everyone knows, are the descendants of Egyptian picture-symbols or hieroglyphs, were in some instances originally based on animal forms. V, for example, represents the last remains of a drawing of the Horned Viper (*Cerastes*) of Egypt (fig. 1285).

Animals make no inconsiderable figure in both prose and

poetry. In fables, from the time of Æsop downwards, they often supply the principal characters. Sterne has immortalized the Starling, Shakespeare and Shelley the Sky-Lark, Poe and Dickens the Raven, Aristophanes and Thoreau the Frog. Other examples are scattered broadcast through the literatures of the world,[1] and to name them would be a work of supererogation. They often supply the *motif* for poetic efforts which express our

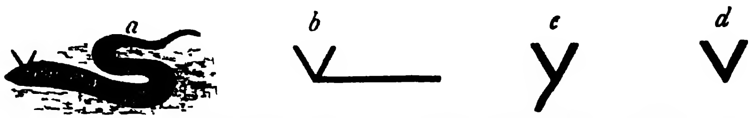


Fig. 125. Evolution of V. *a*, Egyptian hieroglyphic; *b*, abbreviation of same; *c*, Phœnician form; *d*, final form.

sympathy with Nature, and appeal more particularly to those of us who are counted among the worshippers of "the great god Pan". The poem "Enchanted Tones", by J. S. Welhaven, may serve to illustrate this point, and it will be unknown to most readers, for its native language is Norwegian.

"A bird flew over the pine-clad hill
  Of the old, old legends singing,
And carried me out of life's beaten way
  Into dreamland's dim beginning.
I came to the moorland's secret spring
  Where fairies their thirst were slaking,
But ever those magical notes I heard
  'Midst the sighs that the breeze was making.

"I stood in the beech-trees' silver shade
  As the sunset rays low slanted,
When glimmered the dew in the darkling glade
  And on hill shone like gold enchanted.
Then rustled the branches, a sound drew nigh
  As of wings that were rising and falling,
And ever from fell-top, and ever from tree
  Those magical flute-notes were calling.

"Away in the woodland, far away,
  Is the songster's leafy dwelling,
From under the pine-trees, ever and aye,
  His melody's tide is swelling;
And though I never may reach his home,
  The song there is no forgetting,
That sounded sweet when eve's dewy wings
  Shut soft as the sun was setting."

DISTRIBUTION IN SPACE AND TIME

CHAPTER LXXV

GEOGRAPHICAL DISTRIBUTION

To consider, and so far as possible explain, the way in which animals are now spread over the surface of the globe is the province of Geographical Distribution, or, as it is sometimes called, Zoögeography. Alfred Russel Wallace, more than any other man, has been the means of placing this branch of Natural History on a really scientific footing, and his invaluable works *The Geographical Distribution of Animals* and *Island Life* will long remain standard sources of information on the subject. Smaller books by Heilprin and Beddard (*Geographical and Geological Distribution of Animals*, and *Zoogeography*) will also be found extremely useful by the student.

A good deal of information about the parts of the world to which a number of animals belong has already been given in the preceding sections of this work, but certain facts and principles require special mention here, though only elementary treatment is possible, or, it may be, desirable.

Before the theory of evolution became dominant it was commonly believed that any particular kind of animal found within a certain area was specially created there, and speculation was deemed out of place, though it was assumed that one sort of climate suited certain species, and another sort of climate other species. But we are not now contented with the statement "This is so", and always ask "*Why* is this so?" To which question we sometimes get a fairly satisfactory answer.

AREAS OF DISTRIBUTION.—If we consider any kind or species of animal, or any one of the larger groups, such as a genus, a family, an order, or a class, we shall find that it may occupy a limited

or an extensive area, or that it may be found in two or more widely distant parts of the world, and be entirely absent from the intervening regions. The last and perhaps the most interesting case is technically described by speaking of a "discontinuous area of distribution". Believing that existing species have been evolved in course of time from other species, it is pretty obvious that any sort of animal which occupies a restricted area must either have come into existence comparatively recently, or else be an ancient form which has gradually lost ground and is progressing towards extinction. A good example of the latter state of things is afforded by the Tuatara (*Hatteria punctata*), now only to be found on some islets in the Bay of Plenty, off the North Island of New Zealand, upon which larger land-mass we know that it formerly existed. The evidence of geology also proves that it is the last living representative of an order of Reptiles (*Rhychocephala*) which was once widely distributed and dominant, being very likely the parent reptilian group from which all the other orders took origin.

In dealing with questions of distribution it is important to remember that the outlines of land and sea have undergone many changes in the course of the world's history. At various periods, for example, the land-masses of the Old and New Worlds have been connected together in the North, while Australia and the East Indies are the surviving remnants of an extension of the mainland of Asia. Comparatively recent union between land-areas now distinct is often indicated by intervening shallow water, more ancient union by deeper water. From this and other facts we conclude that the British Isles were part of the continent of Europe in comparatively recent times, while many ages have elapsed since Madagascar was continuous with Africa, and the connection of Australia with Asia was still more remote. On the other hand, there are certain small islands isolated in mid-ocean, such as St. Helena and Ascension, which probably never formed part of any existing continent. Using this principle as a basis, Wallace classifies islands as "continental", *e.g.* the British Isles and Madagascar, which once were united with adjacent mainlands; and "oceanic", *e.g.* St. Helena, in which this has never been the case. That such a view explains many of the features of island faunas we shall presently see: the bearing of the former existence of "land-bridges", long since submerged, upon questions

of discontinuous distribution is, for the moment, our immediate concern.

One of the best examples of discontinuous distribution is afforded by the order of Pouched Mammals (*Marsupialia*), now mainly limited to the Australian region, though also represented in America by the Opossums and one other form (*Cænolestes*). Without the aid of the geological record the reason for this would ever remain a matter of the merest conjecture. We know, however, from the evidence this record affords, that in the remote past Pouched Mammals were common enough in Europe, and there are enough facts upon which to base the view that the earliest representatives of the order were evolved in the land-mass of Eurasia. From this area the Pouched Mammals gradually spread, entering what are now America and Australia over tracts of land since submerged beneath the sea. Elsewhere, owing to the competition of more highly specialized mammals, they have died out. But the Australian region having been cut off from the northern land-mass before the higher mammals had a chance of entering it, the pouched forms of that region had a field free from serious competition, in which have since been evolved numerous species adapted to many diverse modes of life. In America they had a harder struggle for existence, and at the present time are poorly represented there, chiefly by Opossums, the ancestors of which no doubt reached the New World by one or more formerly existing land-bridges in the north. There is also good reason for thinking that South America also received a population of pouched mammals from Australia, by means of a southern land-bridge, of which some existing islands appear to be remnants. This Australian stock has since died out almost entirely, being now only represented by two small species of Opossum-Rats (*Cænolestes*), native to Colombia and Ecuador.

Discontinuous distribution explained on somewhat different lines is exhibited by the Lung-Fishes (*Dipnoi*), now represented only in the fresh waters of Africa, South America, and Queensland (see vol. i, p. 264). Once more a clue is afforded by the geological record, from which we know that the ancestors of the Lung-Fishes were at one time a dominant and widely distributed *marine* group. Hard pressed by fishes better adapted to life in the sea, some of them took refuge in estuaries, ultimately passing into the fresh waters of the land. It is only these which

in widely distant parts of the world have left descendants, while all the marine types were doomed to extinction.

DISPERSAL OF ANIMALS.—A species which meets with any success in the struggle for existence increases largely in numbers and, led chiefly by the search for food, comes to occupy a tract of land or sea of continually increasing size (*i.e.* it widens its area of distribution) until prevented by natural causes from migrating farther. The means of locomotion possessed by such a species necessarily plays an important part in the matter. The power of flight, for example, often renders wide dispersal possible, as in the case of Bats. But there are usually certain physical barriers which put a stop to the migratory movements of most kinds of animal. Mammals other than Bats are unable to cross even narrow arms of the sea, while mountain chains and deserts often prove potent checks to further advance And for every other group of land forms obstacles of varying kind present themselves. Even in the case of marine species limits are imposed by temperature, depth of water, supply of suitable food, competition with other species, and so on.

ZOOGEOGRAPHICAL REGIONS OF THE LAND.—It is generally considered that Mammals afford the best means of dividing the land into regions possessing characteristic faunas, and as the areas thus demarcated answer fairly well for Birds, the subdivisions made by W. L. Sclater on this basis, and afterwards adopted by Wallace, will here be given. A reference to the accompanying map (fig. 1286) will show that the boundaries between Sclater's six great regions are largely constituted by physical barriers. Each of these primary subdivisions is again divided into sub-regions. All that can be attempted here is a brief account of the leading features of the large distributional areas, especially with reference to Mammals and Birds. So many incorrect ideas are current, even among educated persons, about the distribution of well-known animals, that no attempt will be made to avoid details that will be commonplace to some readers. Most of the forms of life mentioned in this chapter will be found to have received notice in other connections. It may be well first of all to enumerate the regions and sub-regions.

I. PALÆARCTIC REGION.—Europe,—all but the south of Asia,—and Africa north of the Sahara. Sub-Regions·—1. European; 2. Mediterranean; 3. Siberian; 4. Manchurian.

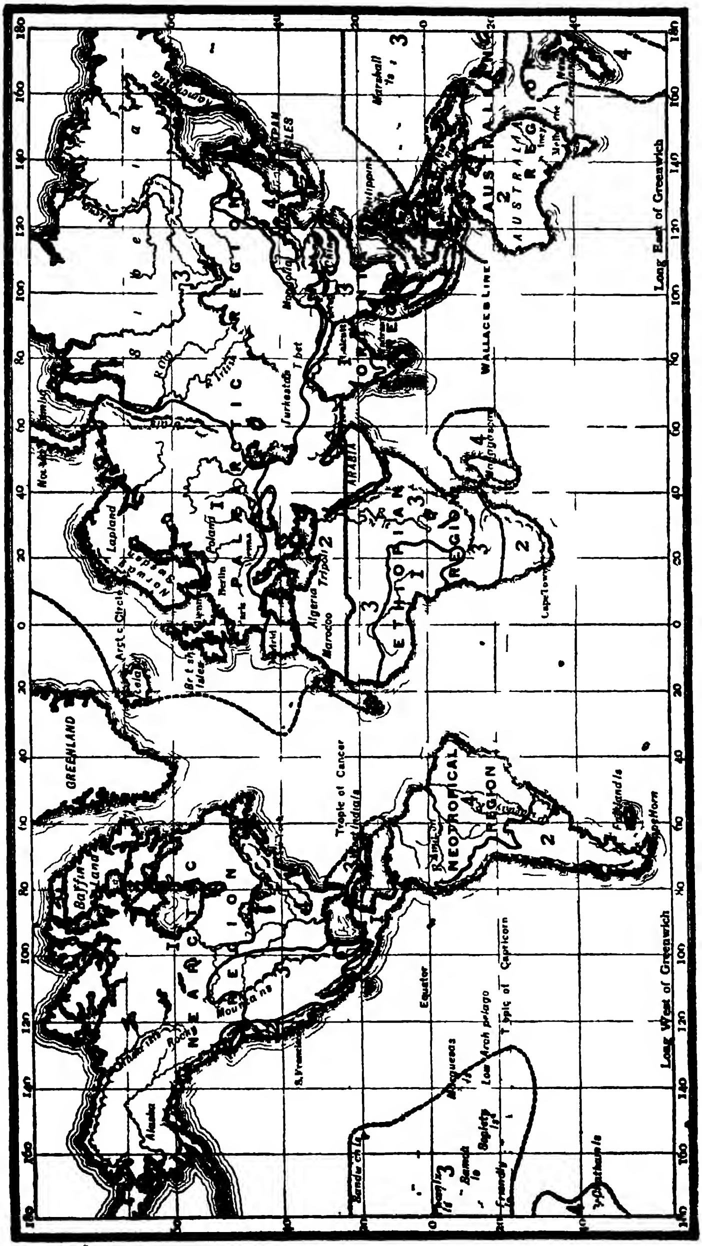


Fig 1286 — Zoogeographic Regions of the Land. The figures indicate the sub-regions (see text)

II. Nearctic Region. — Practically equivalent to North America. Sub-Regions:—1. Canadian; 2. Californian; 3. Rocky Mountain; 4. Alleghany.

III. Ethiopian.—Africa south of the Sahara, south Arabia, and Madagascar. Sub-Regions:—1. West African; 2. South African; 3. East African; 4. Mascarene.

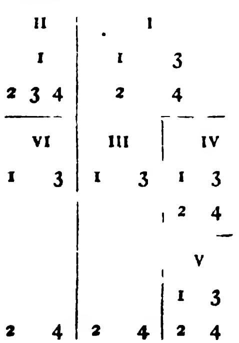
IV. Oriental Region.—South Asia, the western part of the East Indies, the Philippines, and Formosa. Sub-Regions:—1. Indian; 2. Cingalese; 3. Indo-Chinese; 4 Indo-Malayan.

V.—Australian Region.—The eastern part of the East Indies, Australia and adjacent islands, New Zealand, and Polynesia. Sub-Regions:—1. Austro-Malayan; 2. Australian; 3. Polynesian; 4. Novo-Zelanian.

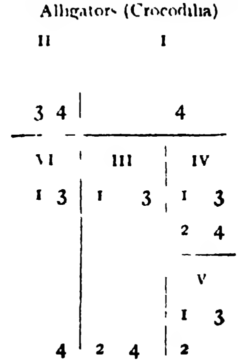
VI. Neotropical Region.—Central America, South America, and the West Indies. Sub-Regions:—1. Mexican; 2. Chilian; 3. West Indian; 4. Brazilian.

Chalmers Mitchell has devised the following ingenious way of representing the regions and sub-regions in a diagrammatic form, which readily lends itself to expressing the distribution of any animal or group of animals, by simply leaving out the numbers of those sub-regions in which that particular form or group does not occur.

Regions and Sub Regions.



Distribution of Crocodiles and Alligators (Crocodilia)



Fauna of the Palæarctic Region.—In spite of its great size this region possesses comparatively few animals which are found nowhere else. The number would be much larger if there were not a good many species common to it and the Nearctic Region. This is not very surprising when we remember the

comparative narrowness of the Behring Straits, across which there was a land-bridge at no very remote period, geologically speaking. At one time, too, Europe and North America were connected by land occupying the North Atlantic, and the sea between Britain and Greenland is still comparatively shallow. It may be objected that even if such unions once existed the rigour of the northern climate would prevent land animals from migrating across them; but we know that there have been many changes in climate during the past history of the globe, and that for part of the time when these land-bridges existed a much higher temperature prevailed in the areas they occupied than is now the case. Besides which, the objection, even if valid, would not apply to Arctic forms; and, further, many animals which we now associate with the warmer parts of the earth are able to endure a larger amount of cold than is sometimes supposed. It may be added that the resemblances between the faunas of the Palæarctic Region and the northern part of North America are so striking that many writers associate these together under the name of the Holarctic Region. This fact is mentioned because in dealing with certain forms it will be convenient to speak of them as being "holarctic".

Palæarctic Mammals (*Mammalia*).—Among Insect-eating Mammals (*Insectivora*) our common Mole (*Talpa Europæa*) and related species of the same genus are confined to this region, as also are the Desmans (*Myogale*), while Hedgehogs (*Erinaceidæ*) are very characteristic, though not peculiar. Of the Flesh-Eaters (*Carnivora*) very few are entirely limited to the region, the most notable being the Raccoon-Dog (*Nyctereutes*, fig. 287) of north-east Asia, and the Common Badger (*Meles taxus*) with some of its immediate allies. It should be stated, however, that a number of Carnivores are purely holarctic, *e.g.* the Polar Bear (*Ursus maritimus*), the Glutton (*Gulo luscus*), Lynxes, and Arctic Foxes; while some others are very characteristic, *e.g.* Wolves, Bears (other than the Polar species), Martens, and Weasels. Some aquatic Carnivores are entirely holarctic, such as the Sea Otter (*Latax lutris*), the Greenland Seal (*Phoca Grænlandica*), the Walrus (*Trichechus rosmarus*), and the Greenland Whale (*Balæna mysticetus*).

The Palæarctic region is comparatively rich in Hoofed Mammals (*Ungulata*) native to no other part of the world. Among these are conspicuous typical Oxen (*Bos*), Goats (*Capra*),

and Sheep (*Ovis*), which are hardly represented elsewhere; also a number of Deer (*Cervidæ*), such as the Fallow-Deer (*Dama vulgaris*), Roe-Deer (*Cervus capreola*), and Water-Deer (*Hydropotes*); while, besides these, certain Antelopes, such as the Chamois (*Rupicapra tragus*) and the Saiga Antelope (*Saiga Tartarica*), are peculiar. Nor must mention of the Camels

Fig. 1287.—Raccoon Dog (*Nycterentes*)

(*Camelus*) be omitted. The Reindeer (*Rangifer tarandus*), Elk (*Alces machlis*), and Musk-Ox (*Ovibos moschatus*) may be mentioned as typically holarctic Ungulates.

Among Gnawing Mammals (*Rodentia*), Dormice (*Myoxus*) and Mole-Rats (*Spalax*) are Palæarctic, while Marmots (*Arctomys*) and Calling Hares or Pikas (*Lagomys*) are holarctic. Beavers (*Castor*), Voles (*Microtus*), Ground-Squirrels (*Tamias*), and most of the Hares and Rabbits (*Lepus*) are also holarctic.

Palæarctic Birds (*Aves*).—Among the genera which are limited to this region are some of those including a number of our familiar British forms, *e.g.* Grasshopper Warbler (*Locustella*), Robin Redbreast (*Erithacus*), "Bearded Tit" or Reedling (*Panurus*), Long-tailed Tit (*Acredula*), Buntings (*Emberiza*), Chaffinch (*Fringilla*), Bullfinch (*Pyrrhula*), Jay (*Garrulus*), Nut-cracker (*Nucifraga*), and Partridge (*Perdix*). Ordinary Pheasants (*Phasianus*) and some of their more ornamental relatives are also very characteristic Palæarctic forms. Some other British birds belong to holarctic genera, *e.g.* Red Grouse and Ptarmigan (*Lagopus*), Capercailzie (*Tetrao*), Divers (*Colymbus*), Razor-Bills (*Alca*), Guillemots (*Uria*), and Puffins (*Fratercula*).

Palæarctic Reptiles (*Reptilia*).—A solitary species of Alligator (*Alligator Sinensis*) is native to South China. Our indigenous Blind-Worm represents a purely Palæarctic genus (*Anguis*) of limbless lizards, while that (*Lacerta*) which includes the Sand-Lizard, Green-Lizard, and Wall-Lizard is hardly represented outside the region.

Palæarctic Amphibians (*Amphibia*).—Peculiar to this region are the genera including the Fire-bellied Toads (*Bombinator*), that form (*Alytes*) in which the male carries about the egg-masses, and the Salamanders (*Salamandra*). It is also interesting to notice that the great majority of Tailed Amphibians (*Urodela*) are limited to the Northern Hemisphere.

Palæarctic Fishes (*Pisces*).—Among British freshwater fishes, Carp and Tench may be mentioned as representing genera (*Cyprinus* and *Tinca*) peculiar to the region, as also are the Gold-fishes, &c. (*Carassius*), of China and Japan. There are also some families of fishes which are very characteristic of the Northern Hemisphere, *e.g.* those containing Pikes (*Esocidæ*), Sticklebacks (*Gasterosteidæ*), and Salmon (*Salmonidæ*). Most of the curious archaic Ganoids (*Ganoidei*) also belong to the same hemisphere. These forms (see vol. i, p. 266) present a good example of a discontinuous area of distribution to be explained in the same way as that of the Lung-Fishes (see p. 266).

Palæarctic Insects (*Insecta*).—Perhaps the most striking feature of the region is the great abundance of predaceous Ground-Beetles (*Carabidæ*) which it possesses, regarding which Wallace says (in *Island Life*) that ". . . the large and handsome genus Carabus, with its allies Procerus and Procrustes, contain-

ing nearly 300 species, is almost wholly confined to this region, and would alone serve to distinguish it zoologically from all other parts of the globe".

FAUNA OF THE NEARCTIC REGION.—It will be remembered that the "holarctic" forms already mentioned are common to the Palæarctic region and northern part of the Nearctic region, and need not, therefore, be mentioned again, though it may be well to state that the Musk-Ox (*Ovibos*) is almost entirely Nearctic

Fig 1288 Star nosed Mole *Condylura*)

Nearctic Mammals (*Mammalia*).—Among the Insect Eaters (*Insectivora*) the Star-nosed Mole (*Condylura*, fig 1288) is the most remarkable of the purely Nearctic forms. A number of the Flesh-Eaters (*Carnivora*) differ from those of the Old World, but as the most important of these are even more characteristic of the Neotropical region, mention of them will be postponed. Two of the Hoofed Mammals (*Ungulata*) are essentially Nearctic, *i.e.* the Pronghorn (*Antilocapra*) and the Rocky Mountain Goat (*Haploceros*). Two families of Gnawers (*Rodentia*) are confined to this region, the Pouched Rats (*Saccomyidæ*), including Gophers, Kangaroo-Rats, and Pocket-Mice, and the Sewellels (*Haplodontidæ*), including two species of small rodents allied to the squirrels but with the habits of marmots. Besides these, two very typical Nearctic genera belong to this order, *i.e.* those to which the Tree-Porcupine (*Erethizon*) and the Prairie-Dogs (*Cynomys*) belong. Opossums (*Didelphyidæ*) represent the Pouched Mammals (*Marsupialia*) in this region, but are more typical of the Neotropical.

Nearctic Birds (*Aves*).—Many of the familiar Palæarctic

species are replaced by members of characteristic American families. There are also a number of peculiar Nearctic genera, but to give a list of them would serve no useful purposes. Turkeys (*Meleagris*) are well represented, but also range south into Central America.

Nearctic Reptiles (*Reptilia*).—It need only be said that poisonous Lizards (*Heloderma*) are characteristic, as also are Rattlesnakes (*Crotalus*), though both range into the Neotropical region, while Crocodiles and Alligators are represented in the south of the United States.

Nearctic Amphibians (*Amphibia*).—The region is richer than any other part of the world in Tailed Amphibians (*Urodela*), and among the peculiar forms are the curious Mud-Eels (*Amphiuma*) and Sirens (*Siren*).

Nearctic Fishes (*Pisces*).—Several families and a considerable number of genera of freshwater fishes are native to this region only, but their names would convey little meaning to average European readers.

Nearctic Freshwater Molluscs (*Mollusca*).—Wallace states that the Nearctic region is richer in characteristic forms than any other part of the world.

Fauna of the Ethiopian Region.—We have seen that the approximation in high latitudes of the great land-masses of the Northern Hemisphere has led to a great deal in common between the faunas of the Palæarctic and Nearctic regions, and both of them are rather deficient as regards the presence of peculiar forms known to the lay reader. This renders it rather difficult to treat them in a popular manner; but there is no such difficulty with regard to the southern regions which remain for consideration, as all of them have well-marked characteristics, and their more typical animals are familiar to everyone. In varying degree they have been more or less isolated by physical barriers for very long periods of time, and this isolation has rendered possible the evolution of distinctive faunas.

Ethiopian Mammals (*Mammalia*).—There is no lack of Apes and Monkeys (*Primates*) belonging to genera not represented elsewhere. Among the higher or man-like Apes the Gorilla (*Gorilla*) and Chimpanzee (*Anthropopithecus*) are typical, while of lower forms may be mentioned the Colobi (*Colobus*) with reduced thumbs, the Guenons (*Cercopithecus*), and a number of

Baboons (*Papio* or *Cynocephalus*). The majority of Lemurs (*Lemuroidea*) are African. The peculiar Ethiopian Insect-Eaters (*Insectivora*) include the Golden Moles (*Chrysochloris*), and an otter-like West African form (*Potamogale*), among many other characteristic types. There are also Flesh-Eaters (*Carnivora*) belonging to purely Ethiopian genera, *e.g.* the Foussa (*Cryptoprocta*) of Madagascar, the Aard-Wolf (*Proteles*), and the Cape Hunting-Dog (*Lycaon*). Though Lion (*Felis leo*)

Fig 1289.—Wart-Hog (*Phacochærus*)

and Leopard (*F. leopardus*) are both very characteristic, the former ranges into Asia (and has only become extinct in Europe during historic times), while the latter so closely resembles the Asiatic Panther (*F. panthera*) that the two animals are often considered as belonging to the same species. A curious negative feature is found in the complete absence of animals of the Bear kind. Of Hoofed Mammals (*Ungulata*) many remarkable forms are limited to the Ethiopian region. They include Zebras (species of *Equus*), characteristic species of Rhinoceros, Wart-Hog (*Phacochærus*, fig. 1289), Red River-Hog (*Potamochærus*), Hippopotamus (*Hippopotamus*), the Giraffe (*Giraffa*), Okapi (*Okapia*), a number of Antelopes, and the little Water-Chevrotain (*Dorca-

therium). Deer and wild Oxen are absent. Gnawers (*Rodentia*) are represented by a number of peculiar forms, of which may be mentioned the Cape Jumping-Hare (*Pedetes*) and the African "Flying"-Squirrels (*Anomalurus*). The archaic order of Mammals Poor in Teeth (*Edentata*) is represented by the Cape Ant-Eater or Aard-Vark (*Orycteropus*), and Pangolins (*Manis*), though the latter are shared with the Oriental region.

Ethiopian Birds (*Aves*).—Among the many peculiar forms it may suffice to mention Plantain-Eaters (*Musophaga*), Colies (*Colius*), Whydah Finches (*Vidua*), Ox-Peckers (*Buphaga*), many of the beautiful little Sun-Birds (*Nectariniidæ*), the Secretary-Bird (*Serpentarius*), and the African Ostrich (*Struthio*).

Ethiopian Reptiles (*Reptilia*).—Crocodiles are abundant but not peculiar, while among Lizards (*Lacertilia*) the large majority of the Chameleons are limited to the region. Among the innumerable Serpents (*Ophidia*) the Egg-eating Snake (*Dasypeltis*) and deadly Puff-Adders (*Bitis*) are purely Ethiopian.

Ethiopian Amphibians (*Amphibia*). — The Clawed Toads (*Xenopus*) are limited to Africa, while, on the other hand, not only are Tailed Amphibians (*Urodela*) entirely absent, but also several families of Tailless Amphibians (*Anura*), *e.g.* the Tree-Frogs (*Hylidæ*).

Ethiopian Freshwater Fishes (*Pisces*).—Some of the most archaic types are limited to the region, *e.g.* one of the Lung-Fishes (*Protopterus*), the Bichir (*Polypterus*), and the Reed-Fish (*Calamoichthys*), the last two being Ganoids.

Ethiopian Land and Freshwater Molluscs (*Mollusca*).—One of the large Land-Snails (*Achatina*) is very characteristic, though not limited to Africa, while Land-Slugs are comparatively scarce, and freshwater molluscs are less abundant than in some other regions. The fauna of Lake Tanganyika presents some remarkable features. As we have seen elsewhere (see p. 313) the Caspian Sea and Lake Baikal were once continuous with the Arctic Ocean, the fact that each is inhabited by a peculiar species of Seal being accounted for in this way. It appears that in remote geological times Tanganyika was also part of a sea area, and was converted into a lake as one of the results of a series of land-upheavals. Some of the marine molluscs and other animals living in the sea of which it formed a part proved able to accommodate themselves to the altered conditions, and

these "halolimnic" forms, some to all appearance closely resembling ancient extinct types, are now found in the fresh waters of this lake, side by side with ordinary freshwater species.

Ethiopian Insects (*Insecta*).—The region is very rich in insect life, but it is not possible here to enter into details regarding the many interesting and beautiful species. Wallace mentions the large and handsome Goliath-Beetles as being especially characteristic, and some of the complex societies of African Termites have been spoken of elsewhere (see p. 124).

FAUNA OF MADAGASCAR.—This subdivision of the Ethiopian region calls for a few remarks, since it is one of the best existing examples of an ancient continental island connected in remote times with the adjacent continent. There can be no doubt that a large part of the Mascarene fauna has been derived from the mainland of Africa, but Madagascar became isolated at a time when that continent did not include among its inhabitants many of the animals by which it is now characterized. Long-standing isolation has also resulted in the evolution of many peculiar species, some of highly remarkable kind. Both the positive and the negative characters of the Mascarene fauna are best illustrated by reference to the Mammals and Birds.

Mascarene Mammals (*Mammalia*).—Of the sixty-six species of Mammals native to Madagascar about half are Lemurs (*Lemuroidea*), representing no less than nine peculiar genera (*Lemur*, *Chirogaleus*, &c.), of which one (*Chiromys*) includes the remarkable Aye-Aye. Except for about fourteen small species shared between the continent of Africa and the Oriental region, these ill-defended creatures are found nowhere else, and their abundance in Madagascar is no doubt to be attributed to the scarcity of carnivores in that island. The case is on a par with that of the Pouched Mammals of Australia. With the single exception of a Shrew the Insect-Eaters (*Insectivora*) of Madagascar belong to the peculiar family of Tanrecs (*Centetidæ*), while the few Gnawers (*Rodentia*) are rats and mice, all belonging to distinctive genera. Flesh-Eaters (*Carnivora*) are only represented by the Foussa (*Cryptoprocta*) and eight kinds of Civet-Cat. Of Hoofed Mammals (*Ungulata*) there is only a species of River-Hog (*Potamochærus*), although the Hippopotamus is known to have been once indigenous. The characteristic Apes and Monkeys, most of the Flesh-Eaters and Hoofed

CHARACTERISTIC ANIMALS OF THE ISLAND OF MADAGASCAR

Madagascar is a good type of "ancient continental islands" that in remote times were connected with the adjacent continents, which they broadly resemble in the nature of their fauna, though the separation has been long enough to render possible the evolution of peculiar species. The Mascarene animals find their nearest allies on the mainland of Africa, the characteristic monkeys, carnivores, ungulates (with one exception), elephants, and ostriches of which are, however, absent. Half the Mammals (33) of the island are Lemurs, one of the most remarkable of which is the Aye-aye (*Chiromys Madagascariensis*, 1), formerly mistaken for a Rodent. A Mouse-Lemur (*Chirogaleus pusillus*) is represented at 2. Most of the Insectivores, of which the Tenrec (*Centetes ecaudatus*, 3) is best known, belong to a family (*Centetidæ*) represented nowhere else.

Of about 150 species of land-birds no less than 127 are peculiar. The two figured are a Fruit-Pigeon (*Alectorœnas pulcherrima*, 4), native to the Seychelles (which belong to the Mascarene sub-region), and a form (*Philepitta jala*, male, 5) related to the so-called "Ground-Thrushes" or Pittas, but constituting with another Mascarene species a special family (*Philepittidæ*).

3

CHARACTERISTIC ANIMALS OF THE ISLAND OF MADAGASCAR

1 -aye. 2 Mouse-Lemur. 3. Tenrec. 4. Fruit-Pigeon. 5. Philepitta

Mammals, and also the Elephants of the African continent are conspicuous by their absence.

Mascarene Birds (*Aves*).—The power of flight possessed by most members of this class to a large extent prevents the evolution of peculiar species by isolation, and we must not therefore expect the land-birds of Madagascar to be so characteristic as the mammals, though it is sufficiently striking to find that out of 238 species no less than 129 are limited to the island, and these include representatives of 35 peculiar genera. We may take as examples two species (of *Philepitta*) of great beauty, allied to the Ground-Thrushes, though constituting a distinct family, and four kinds of Fruit-Pigeon belonging to a genus (*Alectoroœnas*) only represented in Madagascar and some of the smaller islands of the sub-region.

FAUNA OF ST. HELENA.—This typical oceanic island, 1100 miles distant from Africa and 1800 miles from South America, may be taken here as a good illustration of its class. Never having former part of a continent its indigenous fauna naturally presents a strong contrast with that of Madagascar, being entirely made up of such forms of life as have been able to reach it by natural agencies. And since a broad stretch of sea is an insuperable barrier to animals of many kinds, the faunistic characters of St. Helena are largely negative, as in all other such cases. On the other hand, the effect of isolation has been very great, and a large proportion of the species are peculiar.

St. Helena possesses no native Mammals, Land Birds, Reptiles, Freshwater Fishes, or Freshwater Molluscs. There is, however, one peculiar species of Plover (*Ægialitis Sanctæ-Helenæ*) allied to one native to South Africa. Of Land-Snails twenty appear to be indigenous, if we include thirteen that have become extinct in recent times. The Beetles (*Coleoptera*) of the island have been studied with greater care than any other group of insects, and 129 species are native to the island, to which all except one of them are absolutely restricted. More than two-thirds of these beetles are weevils, and, considering the boring habits of such creatures, it is highly probable that the remote ancestors of many of them were conveyed to St. Helena by the agency of drift-wood.

There can be no doubt that many of the animals originally native to this island have become extinct as the result of human

occupation, the introduction of goats having had much to do with this (see p. 346).

FAUNA OF THE ORIENTAL REGION.—The boundaries between this region and the Palæarctic area are in part ill-defined, which naturally means the possession of a number of species in common. The south-eastern boundary, marking it off from the Australian region, is usually known as "Wallace's line", which runs between Bali and Lombok, and thence northwards between Borneo and Celebes. Bali and Borneo thus mark the limit of the Oriental region in this direction.

Oriental Mammals (*Mammalia*).—Taking first the Apes and Monkeys (*Primates*), we find that the higher or man-like Apes are shared between this and the Ethiopian region, for while the Gorilla and Chimpanzee are peculiar to the latter, the Orang-utan (*Simia*) and Gibbons (*Hylobates* and *Siamanga*) are purely oriental. The Proboscis Monkey (*Nasalis*) is restricted to Borneo, while Entellus Monkeys, &c. (*Semnopithecus*), with Bonnet Monkeys and their immediate allies (*Macacus*), mostly belong to this region. It is also the home of three species of Lemur, two of the Loris (or "Slow" Lemurs), and the little Spectre Tarsier. Of the first, one (*Loris*) is restricted to South India and Ceylon, while the other (*Nycticebus*) ranges into the Philippines. The Spectre Tarsier (*Tarsius spectrum*), though chiefly oriental, is also found in Celebes. Two peculiar families of Insect-Eaters (*Insectivora*) are purely oriental, one including the Banxrings or Tree-Shrews (*Tupaiidæ*, fig. 1290), while the only representative of the other is the remarkable Flying-"Lemur" (*Galeopithecus*). There are also two peculiar genera (*Hylomys* and *Gymnura*) of the hedgehog kind. Among Bats (*Chiroptera*) the large Fruit-Bats (*Pteropus*) are characteristic, though not peculiar. Among Flesh-Eaters (*Carnivora*) the Tiger (*Felis tigris*), though very typical, also ranges into North China; but there are a number of peculiar genera belonging to various carnivorous families, while Bears are not absent, as in the Ethiopian region. The Hoofed Mammals (*Ungulata*) are abundantly represented, and some of them are found nowhere else, *e.g.* the little Chevrotains (*Tragulus*, represented in West Africa by *Dorcatherium*), the small Deer known as Muntjacs (*Cervulus*), and certain Antelopes (*Antilope* and the four-horned *Tetraceros*). Rhinoceroses and Elephants (*Proboscidea*) are shared

between this region and Africa. Tapirs (*Tapirus*) are only to be found here and in the Neotropical area. Of Gnawers (*Rodentia*) the most notable are perhaps the Asiatic Flying-Squirrels (*Pteromys*). Mammals Poor in Teeth (*Edentata*) are represented by some of the Pangolins (*Manis*), though some of these are also native to Africa.

Oriental Birds (*Aves*).—Two families of Perching Birds are confined to the region, *i.e.* the Green Bulbuls (*Phyllornithidæ*) and the Broadbills (*Eurylæmidæ*); while some of the many peculiar genera include such better-known forms as the Tailor-Birds (*Orthotomus*), typical Hornbills (*Buceros*), Peacocks (*Pavo*), Peacock-Pheasants (*Polyplectron*), Silver Pheasants (*Gennæus*) and related species, and the Water-Pheasant (*Hydrophasianus*). Highly characteristic, though not entirely limited to this region, are the Jungle Fowl (*Gallus*).

Fig 1290 - Tree Shrew (*Tupaia*)

Oriental Reptiles (*Reptilia*).—Crocodiles (*Crocodilus*) are abundant in the region, and the long-snouted Garials (*Garialis* and *Rhynchosuchus*) are limited to it. Of the numerous Lizards (*Lacertilia*) the pretty little Flying Dragons (*Draco*) are purely oriental. The burrowing Shield-tailed Snakes (*Uropeltidæ*) are found in no other region; and the same is true for one genus (*Bungarus*) of poisonous serpents, including the Krait, which is supposed to work more havoc among the natives of India than any other creature of its kind.

Oriental Amphibians (*Amphibia*).—Though tailed forms (*Urodela*) are represented they are vastly outnumbered by the tailless ones (*Anura*), but none of these call for special mention.

Oriental Freshwater Fishes (*Pisces*).—Most of the Snake-headed Fishes (*Ophiocephalidæ*), which are able to live during the dry season in liquid mud, are limited to the region, and the same is true of the members of a small family (*Mastacembelidæ*) of eel-like forms, which, however, have nothing to do with the true eels.

Oriental Insects (*Insecta*).—Regarding these Wallace remarks (in *Island Life*):—"Among insects we may notice the magnificent golden and green Papilionidæ [*i.e.* Swallow-tail Butterflies] of various genera as being unequalled in the world, while the great Atlas Moth is probably the most gigantic of Lepidoptera, being sometimes 10 inches across the wings, which are also very broad. Among the beetles the strange flat-bodied Malayan Mormolyce is the largest of all the Carabidæ [*i.e.* predaceous ground-beetles], while the Catoxantha is equally a giant among the Buprestidæ. [The beautiful wing-covers of various species of this family are largely used in India for ornamental purposes.] On the whole, the insects of this region probably surpass those of any other part of the world, except South America, in size, variety, and beauty."

FAUNA OF THE AUSTRALIAN REGION.—"Wallace's line" (see p. 413), which divides this region from that last considered, is not the sharply-marked boundary that was at one time supposed, for a considerable number of oriental forms range to the east of it, and Australian forms to the west of it. Some authorities consider that the line should be drawn to the east of Celebes, which would then belong to the oriental region. Wallace's line, if thus amended, would be a somewhat sharper boundary than it is now. New Zealand, too, possesses such well-marked positive and negative features that it should possibly be considered as a distinct (Novo-Zelanian) region, instead of being ranked merely as a sub-region. A few of its peculiarities will be indicated in the following brief sketch.

Australian Mammals (*Mammalia*).—Among the animals found in Celebes are three belonging to peculiar genera, *i.e.* a Black Ape (*Cynopithecus*), a Dwarf Ox (*Anoa*), and the Babirussa (*Porcus* or *Babirussa*, fig. 1291), a curious pig-like form with long curled tusks in the upper jaw. It is also inhabited by a species

of Deer, a Civet-Cat, and five kinds of Squirrel, while the Spectre Tarsier (*Tarsus spectrum*) is said to be found on a small adjacent island. The Deer and Civet-Cat have possibly been introduced. Typical Pigs (*Sus*) range as far east as New Guinea, but with this exception, various Bats, a number of rats and mice, and the doubtfully indigenous Dingo (*Canis dingo*) of the Australian continent, the mammalian fauna of the region (excluding Celebes) is made up of Marsupials (represented in Celebes) and Egg-

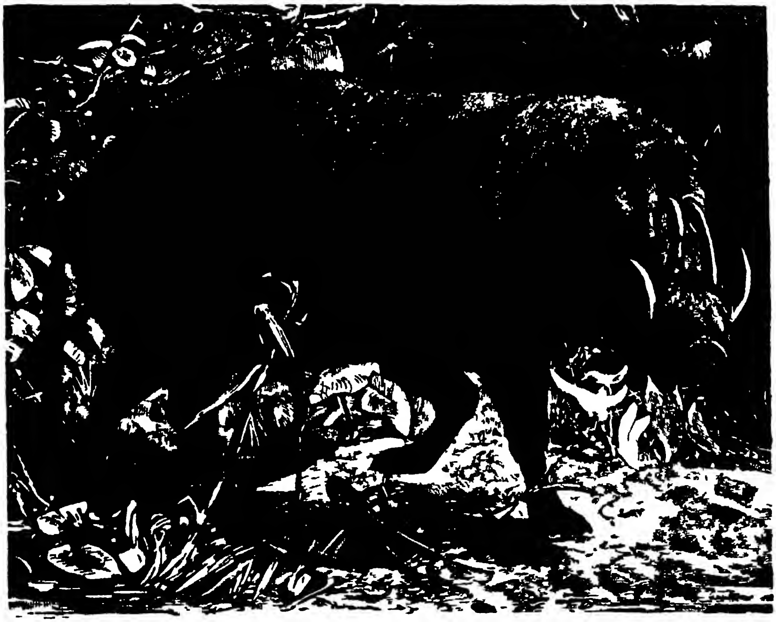


Fig 1291 —Babirussa (*Babirussa*)

laying Mammals (*Monotremata*). The last, which include the Duck-Bill (*Ornithorhynchus*) and Spiny Ant-eaters (*Echidna* and *Proechidna*), are found in no other part of the world, though Marsupials are scantily represented in America. New Zealand is singularly devoid of indigenous mammals, there only being two peculiar species of bat, a doubtful rat, and a problematical otter-like creature.

Australian Birds (*Aves*).—Among the most typical Australian groups are the beautiful Honey-Suckers (*Musiphagidæ*), many distinctive kinds of Parrot and Cockatoo, Birds of Paradise,

Crowned Pigeons, the land Kingfisher (*Dacelo*) familiarly known as the "Laughing Jackass", the "More-Pork" birds (*Podargus*), the Mound-Builders, Cassowaries, and Emus. All these, except Honey-Suckers, Parrots (not Cockatoos), and Pigeons, are represented in New Zealand, but the other birds named are absent. There are, however, some highly peculiar Novo-Zelanian forms, found in no other area. These include the Kea and Kaka Parrots (*Nestor*), the ground-dwelling Owl-Parrot (*Stringops*), and the Kiwi (*Apteryx*), which is the smallest existing representative of the Running Birds (*Ratitæ*). But within the period of human occupation a number of large species of the last-named group existed in the islands, *i.e.* the "Moas" (*Dinornithidæ*), some of which were over 10 feet in height.

Australian Reptiles (*Reptilia*).—Crocodiles range across the northern part of the region as far east as the Solomon and Fiji Islands. Among the numerous Lizards two peculiar to the Australian continent deserve mention, *i.e.* the Frilled Lizard (*Chlamydosaurus*), which can run for some distance on its hind-legs, and the spiny Mountain Devil (*Moloch*). Snakes are found in abundance, but details are unnecessary. New Zealand possesses a number of Lizards (*Geckoes* and *Skinks*), but neither Crocodiles nor terrestrial Snakes. Some small islands in the Bay of Plenty are, however, of peculiar interest, for they are the home of the Tuatara (*Hatteria*), which is the last surviving member of an exceedingly ancient and once widely distributed reptilian order (*Rhynchocephala*), that was very probably ancestral to all the other known groups.

Australian Amphibians (*Amphibia*).—Tailless forms (*Anura*) are well represented in the region, but New Zealand has only one indigenous species of amphibian, a sort of Toad (*Liopelma*).

Australian Fishes (*Pisces*).—The most interesting species native to this region is Ceratodus, a Lung-Fish (*Dipnoi*) now limited to Queensland.

Fauna of the Neotropical Region.—Although the results of isolation are not here quite so well marked as in the case of Australia, to say nothing of New Zealand, the fauna of the region presents many well-marked characteristics, both positive and negative. It affords a refuge to certain archaic forms, which have been able to prolong the tenure of their existence in the absence of large numbers of carnivores, and, for the same reason,

may be regarded as the head-quarters of some other animals which, though not decadent, are comparatively defenceless. On the other hand, the region stands unsurpassed for variety and wealth of life, which is partly due to its unparalleled range in latitude and diversity in altitude. Every kind of climate and environment are exemplified, from the tropical forests of Brazil to the rigour of the high Andes or Tierra del Fuego, from the grassy pampas of the Argentine to the Patagonian desert.

Neotropical Mammals (*Mammalia*).—To this region are absolutely confined the American Monkeys (*Cebidæ*) and the Marmosets (*Hapalidæ*), both (especially the latter) of lower grade than their Old World cousins. Lemurs (*Lemuroidea*) are entirely absent, as from America in general. There are no fruit-eating Bats (*Pteropidæ*), but a number of genera are peculiar to the region, especially those including the blood-sucking Vampires (*Desmodus* and *Diphylla*). A somewhat remarkable negative feature of the Neotropical fauna is the almost complete absence of Insect-Eaters (*Insectivora*). The widely distributed Shrews (*Soricidæ*) are, however, represented in Central America, while the Agoutas (*Solenodon*) of Cuba and Hayti constitute a distinct family.

Of the most predaceous Flesh-Eaters (*Carnivora*), *i.e.* the members of the Cat Family (*Felidæ*), there is a decided scarcity, the three largest indigenous species - Puma (*Felis concolor*), Jaguar (*F. onca*), and Ocelot (*F. pardalis*) also ranging into North America. The Civet Cat Family (*Viverridæ*) is entirely unrepresented; while of Bears (*Ursidæ*) there is only the Spectacled Bear (*Ursus ornatus*) of Peru and Chili. Weasels (*Mustelidæ*) and creatures of the Dog Family (*Canidæ*) are fairly abundant. On the other hand, the Neotropical region is the head-quarters of the almost purely American family of Raccoons (*Procyonidæ*) and their allies. The Kinkajou (*Cercoleptes*) is limited to the region, the long-snouted Coatimundis (*Nasua*) range as far north as Texas, while the Raccoons (*Procyon*) have a wide distribution in the New World. One member of this family is native to the Old World, *i.e.* the Panda (*Ælurus*) of the south-eastern Himalayas, and we have here therefore a good example of discontinuous distribution.

The positive and negative characteristics of the region as regards Hoofed Mammals (*Ungulata*) are both well marked.

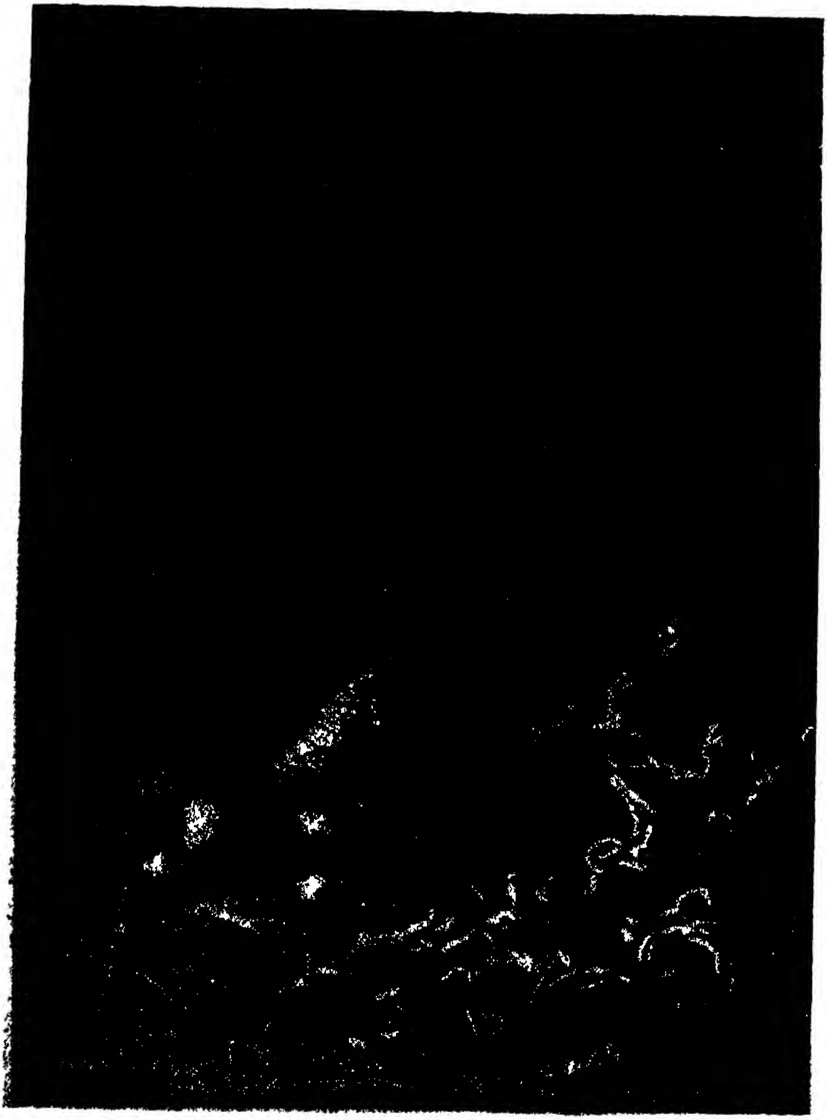
The Odd-toed Ungulates (*Perissodactyla*) are only represented by the archaic Tapirs (*Tapirus*) of South and Central America. They are one of the stock examples of discontinuous distribution, being also found in south-east Asia. As in many similar cases they are the last surviving representatives of a once widely distributed group (compare p. 410). There is also a scarcity of Even-toed Ungulates (*Artiodactyla*), for of non-ruminants there are only the little Peccaries (*Dicotyles*), which differ in many ways from the Swine of the Old World. They also range into the south of the Nearctic region. Among the Ruminants or Cud-Chewers (*Ruminantia*) the Deer Family (*Cervidæ*) is represented by a number of species belonging to two genera exclusively American. One of these (*Pudus*) only includes a very small form (*P. humilis*), native to the Chilian Andes, and of which the male possesses tiny spikes by way of antlers. Most of the species belonging to the other genus (*Cariacus*) are restricted to the Neotropical region, but the largest forms, *e.g.* Virginian and Mule Deer, which also have the most complex antlers, are Nearctic. The large family (*Bovidæ*) embracing Sheep, Goats, Antelopes, and Oxen, which has but few representatives in the Nearctic region, here has none at all. The Camels of the Old World are also absent, but the Guanaco (*Lama guanacus*) and Vicuñia (*L. vicunia*) belong to the same family (*Camelidæ*), and furnish another typical example of discontinuous distribution.

Gnawers (*Rodentia*) are extremely numerous in the Neotropical region, and among peculiar forms may be noted the Cavies (*Caviidæ*), which include the largest existing Rodent (*Hydrochærus capybara*), the Agoutis (*Dasyproctidæ*), and the Chinchillas (*Chinchillidæ*). The archaic and decadent order of Mammals Poor in Teeth (*Edentata*) is also better represented here than anywhere else, for typical Ant-eaters (*Myrmecophagidæ*), Sloths (*Bradypodidæ*), and Armadilloes (*Dasypodidæ*) are only to be found in South America. As to Pouched Mammals (*Marsupialia*), the Opossums (*Didelphyidæ*) are native to both Americas, while the Opossum Rats (*Cœnolestes*) belong to Colombia and Ecuador.

Neotropical Birds (*Aves*).—The region stands unsurpassed for the richness and variety of its avifauna, while a great many families and genera are represented nowhere else, and some of the most distinctive forms are only shared with the Nearctic area.

THE GREAT ANT-EATER (*Myrmecophaga jubata*)

The southern land-masses constitute the last refuge of a number of archaic groups, among which are the Mammals poor in Teeth (*Edentata*), that are most abundantly represented in South America. The plate represents the Great Ant-eater (*Myrmecophaga jubata*), one of the most remarkable Edentates native to that continent. If the long tail is included, its total length may be over 7 feet. The digits of the inwardly turned fore-feet are armed with long sharp claws, well adapted for tearing open ant-hills, and also serving as formidable defensive weapons. The small mouth is placed at the end of a long narrow snout, and the jaws are toothless. Ants are secured by means of the long protrusible tongue, which is made sticky by the abundant secretion of enormous salivary glands. The Great Ant-eater is a ground-animal, but some of its immediate relatives are small arboreal creatures.



THE GREAT ANT-EATER (MYRMECOPHAGA JUBATA)

ONE OF THE MOST REMARKABLE ANIMALS OF SOUTH AMERICA

Of Perching Birds (*Passeres*) a number of families are peculiar, and of these the following are among the most typical:—Manakins (*Pipridæ*), small birds which resemble the Tits in appearance and habits. The large family of Chatterers (*Cotingidæ*), which include the Umbrella-Bird (*Cephalopterus ornatus*), so named from its large overhanging crest of feathers, and the clear-toned Bell-Bird (*Chasmorhynchus*). The Tree-Creepers or Picucules (*Dendrocolaptidæ*) vary remarkably in appearance and in the nature of their nests (see vol. iii, p. 463), while some of the insectivorous Ant-Thrushes (*Formicariidæ*) give notice by their twittering of the approach of armies of Foraging Ants (*Ecitons*). We have also the American "Orioles" (*Icteridæ*), among which are the Cow-Birds (*Molobrus*), some of which, like Cuckoos, lay their eggs in the nests of other species (see p. 186). The true "singing birds" (*Oscines*) of the Old World are comparatively ill represented in this region, the feathered inhabitants of which appeal more to the eye than the ear. Thrushes, however, are abundant.

Among Picarian Birds (*Picariæ*) the brilliantly coloured large-billed Toucans (*Rhamphastidæ*) constitute a family peculiar to the region. A well-known and remarkable family common to South and North America is that of the Humming-Birds (*Trochilidæ*), which for beauty of form and plumage have few serious rivals. Though they range as far north as Alaska, their head-quarters are in the Neotropical region, which is the home of some 400 species, about four-fifths of the total number.

Of Parrots (*Psittaci*) there are a number of genera not represented elsewhere, and the gorgeous long-tailed Macaws (*Conuridæ*) make up a family widely distributed through the region, though also ranging into the Nearctic area.

Among true Game-Birds (*Gallinæ*) the large and handsome Curassows and their allies, which are related to the Mound-Builders of the Australian region, constitute a family (*Cracidæ*) which is almost entirely neotropical. The remarkable Hoatzin (*Opisthocomus cristatus*), native to the northern part of South America (see vol. iii, p. 472), may perhaps be regarded as an aberrant game-bird, but it possesses so many structural peculiarities that it is placed in a distinct family (*Opisthocomidæ*), while some authorities even consider that it is entitled to an order (*Opisthocomi*) of its own.

The South American forms known as Tinamous, sufficiently like game-birds to have earned the local name of "partridges", are in reality very primitive forms, which constitute a distinct order (*Crypturi*). One of the South American Birds of Prey (*Accipitres*), the huge Condor (*Sarcorhampus gryphus*) of the Andes, a kind of Vulture, is the largest existing flying bird, its spread of wing being as much as 9 feet.

The only Running Birds (*Ratitæ*) native to the New World are the Rheas (*Rhea*) or South American Ostriches, which are smaller and less specialized than their African cousins.

Neotropical Reptiles (*Reptilia*).—The warmer parts of the region are inhabited by Crocodiles (*Crocodilus*), and forms known as Caimans (*Caiman*), which are pretty closely related to the Alligators. Among the many Lizards (*Lacertilia*) members of the Iguana Family (*Iguanidæ*) are conspicuous, though the group is shared with North America, and there are outlying forms in Madagascar and the Fiji Islands. The type-genus (*Iguana*) is only represented in tropical America and the West Indies, while the curious Basilisks (*Basiliscus*) are limited to the former area. The Sea-Lizard (*Amblyrhynchus cristatus*) of the Galapagos Islands is remarkable from its habit of browsing on seaweeds which grow on the sea-floor in shallow water.

Snakes (*Ophidia*) are well represented in the Neotropical region. They include most of the species of Boa, and the gigantic Anaconda (*Eunices murinus*), which is the largest known serpent. The harmless Coral-Snake (*Ilysia scytale*), coral-red with black rings, is native to tropical South America. Of this species Gadow remarks (in *The Cambridge Natural History*) that, "On account of its beauty, perfectly harmless nature, and for 'cooling purposes', this snake which grows to nearly a yard in length, is sometimes worn as a necklace by native ladies". The name Coral Snake is also applied to a virulently poisonous species (*Elaps corallinus*) native to the same area and also to the Lesser Antilles. It is related to the Cobras and Kraits of India, and the Death-Adders of Australia.

Amphibians (*Amphibia*).—Though tailed forms (*Urodela*) just get into the northern part of the region, the vast majority of its Amphibians are Frogs and Toads (*Anura*). The tongueless and toothless Surinam Toad (*Pipa Americana*), native to the north of South America, is one of the most interesting species,

which has been spoken about elsewhere, as also have some other neotropical forms (see vol. iii, p. 437).

Neotropical Freshwater Fishes (*Pisces*).—A large eel-shaped Lung-Fish (*Lepidosiren*) is peculiar to South America, and the order (*Dipnoi*) to which it belongs is only elsewhere represented in Africa and Queensland (see p. 411).

In ordinary Bony Fishes (*Teleostei*) the region is extremely rich, and a few peculiar forms require mention. One family (*Osteoglossidæ*) is remarkable in the fact that its geographical range closely corresponds with that of the Lung-Fishes, except that it also includes Borneo and Sumatra. One of the neotropical species (*Arapaima gigas*), abundant in the great rivers of Brazil and the Guianas, is the largest freshwater representative of the order, for it may grow to a length of over 15 feet, and attain a weight of more than 400 lbs. Some of the neotropical members of the widely distributed Cat-Fish Family (*Siluridæ*) are small forms distinguished by their armoured skins. The Electric Eels (*Gymnotidæ*) are characteristic of tropical America.

Most Sharks and Rays (*Elasmobranchii*) are typically marine, yet some of the Sting-Rays (*Trygonidæ*) are at home in the great rivers of South America, though the Indian Ocean is the head-quarters of the family.

Neotropical Land-Molluscs (*Mollusca*).—The Neotropical region is particularly rich in members of this group, the West Indies being especially so, but it is unnecessary to enter into details. One curious negative feature is the complete absence of all members of the family (*Limacidæ*) that includes the ordinary Land-Slugs of the Old World, these being replaced by other types.

Neotropical Insects (*Insecta*).—Regarding these Wallace makes the following remarks (in *The Geographical Distribution of Animals*):—"The Neotropical region is so excessively rich in insect life, it so abounds in peculiar groups, in forms of exquisite beauty, and in an endless profusion of species, that no adequate idea of this branch of its fauna can be conveyed by the mere enumeration of peculiar and characteristic groups. . . . The Butterflies of South America surpass those of all other regions in numbers, variety, and beauty; and we find here, not only more peculiar genera and families than elsewhere, but, what is more remarkable, a fuller representation of the whole series of families."

It is very interesting to note that in the tropical forests of South America the carnivorous beetles, which in countries like our own live upon the ground, have taken to an arboreal life. They are, in fact, driven from their natural domain by predaceous Ants, the habits of some of which have elsewhere been mentioned (see vol. ii. p 104).

CHAPTER LXXVI

LIFE IN DIFFERENT SURROUNDINGS—SHALLOW WATER, DEEP WATER, AND SURFACE FAUNAS OF THE SEA

In writing this book an attempt has been made to illustrate some of the innumerable ways in which animals have become adapted to exist in various surroundings or environments. Occasion has been taken to consider pretty fully adaptations to various kinds of food, to the exigencies of life in water, on the ground, in the ground, among the trees, and in the air. It may therefore perhaps suffice here to deal with a few facts having reference to the adaptations which have been evolved in relation to existence in the sea, especially as the last chapter has been mainly devoted to land animals.

In dealing with marine forms it is found convenient to divide the oceans into three zones which pass into one another, the Neritic, the Abysmal, and the Pelagic, each of which is characterized, broadly speaking, by a special fauna. The Pelagic zone includes the surface waters so far as penetrated by light to any marked extent; the Neritic zone extends from high-tide mark to a depth of 500 fathoms; and the Abysmal zone stretches from this into the deepest and gloomiest ocean abysses.

It is further the practice to divide marine animals into the three groups of Benthos, Nekton, and Plankton, according to their locomotor possibilities. In the Benthos are included fixed forms, and animals which creep upon the sea-floor, or burrow in stone, sand, or mud. Adult corals, for instance, possess no power of moving from place to place, most crabs and sea-snails live on the sea-floor, while many annelids and most bivalves burrow. The Nekton is made up of animals, *e.g.* cetaceans and fishes, which are powerful swimmers and easily range from place to place of their own free-will. The Plankton fauna consist of weaker creatures, and numerous larvæ, which float or

drift with the currents, against which the swimming powers that many of them possess can make no headway, though useful in a minor degree. Such are various animalcules, small crustaceans, jelly-fishes, and salps. Floating eggs and innumerable larvæ also belong to the Plankton.

THE NERITIC ZONE—LIFE IN SHALLOW WATER

The Neritic Zone embraces the area between tide-marks, *i.e.* the littoral sub-zone and the shallow waters adjacent. There being abundant light a great variety of colours and patterns are exhibited by the animals, many of these being useful to their possessors in one way or another. And, as might be anticipated, neritic animals mostly possess well-developed eyes, unless they happen to have become adapted to a burrowing mode of life. The fauna of this zone is rich in the extreme, its character varying with climate and the nature of the sea floor, among other determining circumstances. The intertidal area is of particular interest, for, being exposed to the action of the air at periodic intervals, it is intermediate in character between sea and land, presenting an environment which has rendered possible the evolution of certain terrestrial forms (see vol. ii. p. 459), some of which have again more or less reverted to the ancient aquatic existence.. Land-Crabs, for instance, have sprung from purely marine forms, while Cetaceans have undergone a secondary adaptation to the original mode of life that characterized their exceedingly remote fish-like ancestors.

Neritic Mammals (*Mammalia*). A number of forms which partly belong to the land have more or less claim to be included in the fauna of this zone, though some of them also spend more or less of their time in the Pelagic area. Such in particular are the Sea-Lions or Eared Seals (*Otaridæ*), Walruses (*Trichechidæ*), and Seals (*Phocidæ*), which make up a special group (*Pinnipedia*) of the Flesh-Eaters. The Sea-Cows (*Sirenia*), including the Dugong (*Halicore*) and Manatee (*Manatus*), have deserted the land entirely, though the latter pass up into rivers and are therefore, in part, members of the freshwater fauna.

Neritic Birds (*Aves*).—The nature of the development of birds prevents them from deserting the land altogether, but many species spend so large a part of their lives on the shore or in

shallow water that some allusion to them is necessary here. Among forms which still make considerable use of the land, other than for nesting purposes, the Gulls (*Laridæ*) may be particularly mentioned, and many others have been dealt with in earlier sections, while the Penguins (*Impennes*) are as neritic as it is possible for members of the class to be.

Neritic Reptiles.—The only case requiring mention is that presented by the Sea Lizard (*Amblyrhynchus cristatus*), which spends a large part of its time feeding on the sea-weeds that grow in the shallow water.

Neritic Fishes (*Pisces*).—These are immensely numerous, and many of them have been dealt with in other sections. The majority of food-fishes, for instance, are neritic, though those of the herring and mackerel kind furnish important exceptions, yet many of these pelagic species favour the zone of shallow water for spawning purposes. The beautiful forms which abound in the neighbourhood of coral-reefs would alone require considerable space to do them justice. The effect produced upon the imagination by the coral fauna is vividly summarized by Alcock (in *A Naturalist in Indian Seas*) in the following impressionist sentences:—"Looking back after thirteen years, I can only remember visions of fairy groves and glades, lit by a strange ethereal light, half moon half sun, where, among Christmas-trees of purple and blue and golden green, fishes painted like butterflies flitted and hovered". Those who desire to get some notion of the colour-schemes presented by such a fauna are referred to the magnificent plates in Saville Kent's *Great Barrier Reef of Australia*. There are naturally a large number of interesting adaptations to be found among reef-animals, one of which has elsewhere been described (see p. 171). An interesting protective arrangement is found in a Coral-Fish (*Epinephelus hexagonatus*, fig. 1292) common in the Andaman Islands. The dark polygonal patches on its skin harmonize very well with the particular corals among which it feeds. A modification of different kind is presented by the Parrot-Fishes (*Scarus*), which owe their name to the strong curved jaws that enable them to browse upon the branches of various sorts of coral.

Many British fishes of no economic value haunt the neighbourhood of the coast, or may be seen in tidal pools. Such are some of the Gobies (*Gobiidæ*), which include the beautiful Dragonets

(*Callionymus*), and, in warmer countries, the little Mud-Skippers (*Periophthalmus* and *Boleophthalmus*), the habits of which have already been noticed. Other families are those which include the Blennies (*Blenniidæ*), many of the Bull-Heads (*Cottidæ*), and the gorgeously tinted Wrasses (*Labridæ*). There are also the curious Pipe-Fishes (*Syngnathidæ*), remarkable for the brood-pouch possessed by the male, and among these are the Sea-Horses (*Hippocampus*, *Phyllopteryx*, &c.), which are not found in British seas.

Primitive Vertebrates (*Protochordata*) *of the Neritic Zone.*—Lancelets (*Amphioxus*) and Acorn-headed Worms (*Balanoglossus*)

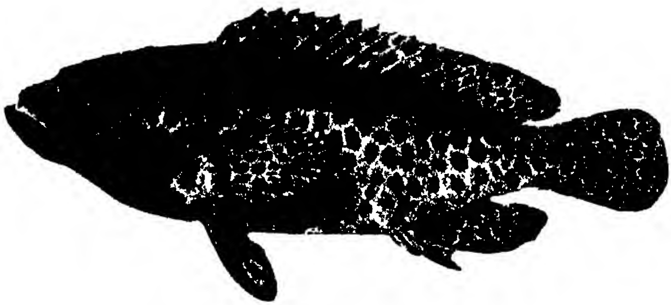


Fig. 1292.—Coral-Fish (*Epinephelus hexagonatus*)

are widely distributed neritic forms, with burrowing habits. The zone is also inhabited by large numbers of Ascidians or Sea-Squirts (*Urochorda*), some solitary and some colonial, which in their adult stage are attached to various objects.

Neritic Molluscs (*Mollusca*).—Head-footed Molluscs (*Cephalopoda*) abound in shallow water, Squids and Cuttle-Fishes, for instance, being found in large numbers around our own coasts, while eight-armed forms, such as the Poulpe (*Octopus*) and its allies, belong as much to the Benthos as to the Nekton, of the Neritic region, for they crawl as much as they swim, or possibly more so.

Sea-Snails and Sea-Slugs (*Gastropoda*) simply swarm both in shallow water and between tide-marks, especially in the tropics. Among the commonest littoral forms on the British coasts are the Limpets (*Patella*), which adhere so closely to the rocks that they defy the wash of the tide, to which their conical shell affords but little purchase; the Purple-Shells (*Purpura lapillus*), well

protected against the buffets of the waves when withdrawn into their thick white dwellings; and the Periwinkles (*Littorina*), including the edible species (*L. littorea*); a smaller, more rounded kind (*L. obtusata*), often of bright-orange hue, which crawls over brown sea-weeds; and a third sort (*L. rudis*), that dwells near high-water mark and has its breathing organs modified in consequence (see vol. ii, p. 459). Sea-Lemons (*Doris*) and other marine slugs are also common.

Among neritic Bivalves (*Lamellibranchia*) forms of economic importance may be mentioned, such as the Oysters (*Ostrea*), attached by the substance of one valve; the Edible Mussels (*Mytilus*), moored by silky byssus threads; the Scallops (*Pecten*), some of which can swim by opening and closing their shells; and the Cockles (*Cardium*), which burrow in the sand. Other delvers in sand or mud are the Gapers (*Mya*), the Razor-Shells (*Solen*), and many more; while Piddocks (*Pholas*) and Date-Shells (*Lithodomus*) are able to excavate dwellings in stone.

Of Primitive Molluscs (*Amphineura*) the flattened Mail-Shells (*Chiton*) live under stones or in rock-crevices.

Neritic Crustaceans (*Crustacea*).—Prominent among these are the Prawns, Shrimps, Lobsters, and Crabs, of many species. Some forms of the last kind which we commonly see on our own coasts are the Edible Crab (*Cancer pagurus*), the green Shore-Crab (*Carcinus mænas*), and, near low-tide mark, the little flattened Porcelain Crabs (*Porcellana*).

Neritic Annelids (*Annelida*).—Of these there is a vast host. Of British forms may be mentioned the actively-creeping Sea-Centipedes (*Nereis*) and many related species; the Sea-Mice (*Aphrodite*), short plump worms with beautiful iridescent bristles; Scale-Worms (*Polynoe*); Lug-Worms (*Arenicola*), that burrow in sand or mud; Sand-Worms (*Sabellaria*), living in communities and gluing grains of sand into dwellings; and various species sheltered in white calcareous tubes, sometimes irregular in shape (*Serpula*), or coiled into small flat spirals (*Spirorbis*) attached to brown sea-weeds.

Other Worm-like Animals of the Neritic Zone.—Here may be mentioned, in passing, the colonial Moss-Polypes (*Polyzoa*), of which the branching skeletons are often taken for sea-weeds; Nemertine Worms (*Nemertea*), slimy unsegmented creatures often found coiled up under stones; Siphon-Worms (*Sipunculus*), that

burrow in the sand; and Turbellarian Worms (*Turbellaria*), variously shaped flattened forms often seen adhering to stones or other objects.

Neritic Hedgehog-Skinned Animals (*Echinodermata*).—In warmer seas, and to some extent in our own, Feather-Stars (*Comatula*) climb or swim in shallow water. Ordinary Star-Fishes (*Asteroidea*) use their numerous tube-feet for creeping, and Brittle-Stars (*Ophiuroidea*) progress on the sea-floor by

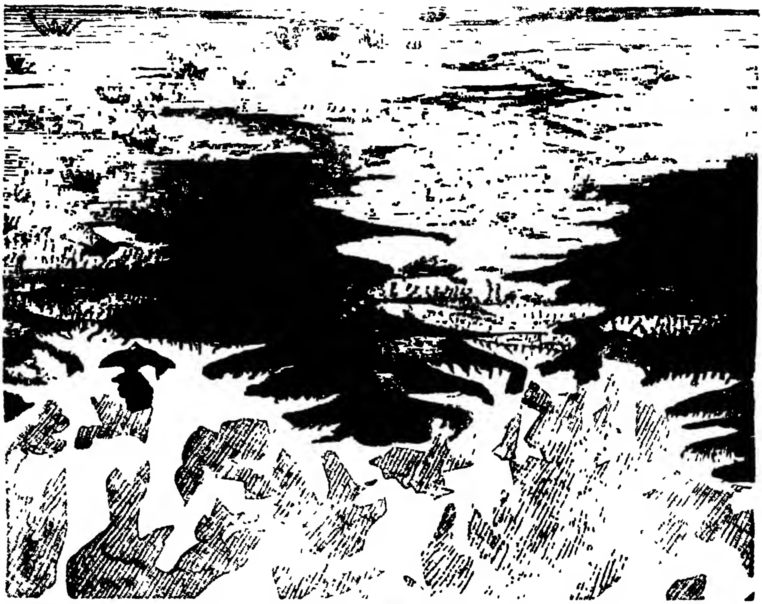


Fig. 1293.—Section through part of a Coral Reef

means of their snake-like arms. Sea-Urchins (*Echinoidea*) creep slowly about after the fashion of star-fishes, and their tube-feet adhere so strongly to rock-surfaces that some of them can even withstand the surf of coral-reefs. The Sea-Cucumbers (*Holothuroidea*) of shallow water either creep or burrow.

Neritic Zoophytes (*Cœlenterata*).—On British coasts the solitary Sea-Anemones, often beautifully coloured, are the most noticeable of the Sea-Flowers (*Anthozoa*). The fauna of the Great Barrier Reef of Australia includes some creatures of this kind which are as much as 2 feet in diameter when fully expanded. In some of the warmer seas, where the water is sufficiently clear,

reefs are built up from the dead skeletons of a bewildering variety of Corals, simple or colonial, and the animals to which they belong are closely related to the sea-anemones. Some Corals live on the floor of the deep sea, but the reef-builders, so far as we know, cannot exist in water deeper than about 40 fathoms. Since some reefs extend downwards into much greater depths (their foundations consisting of the skeletons of dead polypes, fig. 1293), Darwin came to the conclusion that such reefs had been formed in areas where the sea-floor was sinking, but at so slow a rate that upward growth kept pace with it. The theory affords a simple explanation of the ring-shaped reefs known as atolls, which might be supposed to have come into existence from the gradual sinking of islands fringed by reefs (figs 1294, 1295). Borings recently made on coral islands lend strong support to the hypothesis.

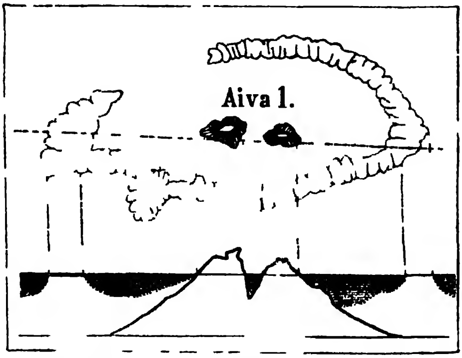


Fig 1294 —An encircling Coral Reef in Plan and Section By gradual sinking of the island with corresponding upgrowth of coral, an atoll fig 1295 might be formed

Fig 1295 —An Atoll

The population of the Neritic zone further includes large numbers of hydroid zoophytes and jelly-fishes (*Hydrozoa*), these being in some cases the fixed and free-swimming stages in the life-history of the same species.

THE ABYSMAL ZONE—LIFE IN DEEP WATER

The Abysmal Zone includes that part of the sea into which daylight penetrates but little, if at all. Even the average depth of the ocean, taken as a whole, is about 2100 fathoms (12,600 feet), while the profoundest abysses may be more than double this. The deepest patch at present known is off the coast of New Zealand, where a sounding of over 5000 fathoms (30,000 feet) has been obtained. It was long supposed that the deep sea was entirely devoid of life, but the numerous scientific investigations made during the last few decades have proved that even at great depths there is a rich and varied fauna, closely allied to that of the Neritic zone, but presenting many peculiar features in relation to the entirely different physical conditions. Except where this realm adjoins the Pelagic zone above it, it is probably in complete darkness so far as daylight is concerned, though it is more or less lit up by the phosphorescent glow given out by many of its inhabitants. The pressure is enormous, and the deep sea is also very cold, the temperature of its floor not being far removed from freezing-point. There is a complete absence of plants (except perhaps bacteria), and many of the animals are consequently predaceous in a marked degree. The requisite supply of food is maintained by the dead organisms which rain down from the Pelagic zone, or get washed in at the sides from the Neritic zone. Deep-sea animals present a great variety of colours, though no one tint can be said to characterize the fauna as a whole, and there is generally no blending of different hues in the same animal, nor any complex patterns or markings. It would seem that the utilitarian explanations that are more or less applicable to the colour-schemes of neritic forms fall short here. Certain other features will best be explained by briefly reviewing some of the chief groups of animals.

Deep-Sea Fishes (*Pisces*).—Most of the fishes of the deep sea are black or brown in colour, but some of them are purple, pink, or red, and since these brighter hues are most prevalent in the upper regions of the abyss, at depths of from 100 to 250 fathoms, it is not impossible that they may correspond to a dull kind of sunset illumination due to light which has filtered down from the surface. Many deep-sea fishes are also characterized by the possession of variously arranged phosphorescent organs on

the head and body, but the use of these can only be conjectured in most cases. In some of the Deep-Sea Anglers (e.g. *Melanocetus Murrayi*) a luminous knob at the end of the "lure" almost certainly serves the purpose of attracting prey (see vol. ii, p. 85). The bodies of these abysmal forms are of great fragility, and there is a deficiency of lime in their skeletons. Huge mouths, provided with formidable teeth, associated with swallowing powers of no mean order, distinguish many species, giving them a hungry

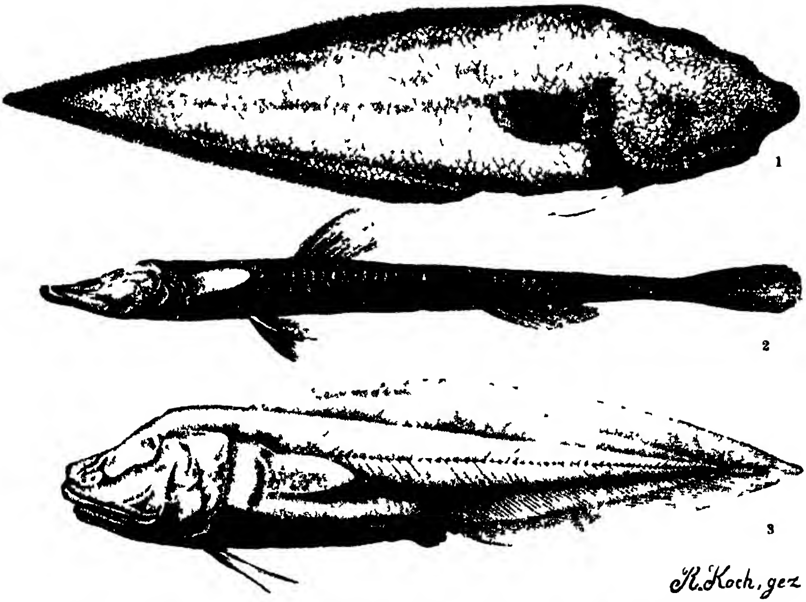


Fig 1296.—Blind Deep Sea Fishes 1, Typhlonus nasus 2, Ipnops Murrayi 3, Aphyonus gelatinosus.

and ferocious appearance, and suggesting that no chance of a square meal is let slip. In the manner of sight there are startling differences which at first appear difficult to reconcile. In most cases the eyes are either large and owl-like, serving to catch the faintest rays of light, or else they are degenerate, sometimes, indeed, having entirely disappeared (fig. 1296). It is usually supposed that those fishes descended from ancestors which exchanged neritic for abysmal life with sufficiently plastic eyes, so to speak, to render their adaptation to the new conditions possible, have gradually acquired exaggerated positive characteristics, while the blind or purblind forms have taken origin from ancestors in

which such plasticity was absent. It is also clear that species which spend more or less of their time in the uppermost part of the abyss (and even in the Pelagic zone) have a better chance of improving their organs of vision. But the matter is still in the conjectural stage.

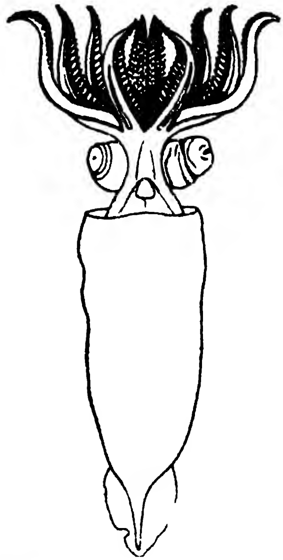


Fig. 1297.—Deep-sea Cuttle-Fish (*Taonius abyssicola*) with large eyes

Some of the fishes which see indifferently or not at all partly make up for the deficiency by the possession of long feelers, derived from fin-rays, which serve as a means of exploring the surrounding area to some distance (see p. 28).

Deep-Sea Molluscs (*Mollusca*).—Some of the deep-sea Cuttle Fishes (e.g. *Taonius abyssicola*, fig. 1297) are distinguished by the possession of exceptionally large eyes. The species figured has been dredged from depths of 902–1370 fathoms in the Indian Ocean. There are also several curious Octopods (see vol. iii, p. 33). The Snails and Bivalves possess unusually thin and fragile shells, while some of the former have lost the characteristic rasping-organ (*odontophore*)

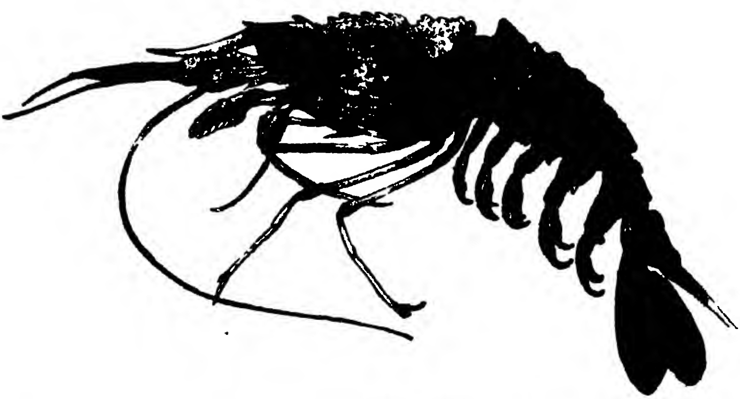


Fig. 1298.—Deep Sea Prawn (*Glyphocrangon priononota*) with large eyes, and well developed organs of smell

Deep-Sea Crustaceans (*Crustacea*).—Pink and red are here the prevailing colours, but some forms are purple, yellow, cream-

colour, red, and even white, while others are spotted or striped in a simple manner. The hard investment of the body is comparatively thin and free from lime. As among Fishes, we find that the eyes are either greatly developed, or else more or less degenerate. We may take as an example of the former condition a kind of Prawn (*Glyphocrangon priononota*, fig. 1298) inhabiting the Indian Ocean at depths of 865–1022 fathoms. The figure illustrates two other interesting features. One branch of the first feelers (the thicker of the two filaments seen projecting in front) is of large size, and as this is the region which bears the olfactory organs the possession of a keen sense of smell may be inferred. There is, further, a sharp defensive spine at the end of the tail, which can be turned up and held in that position by a sort of "locking joint", acting as a bayonet to repel enemies at close quarters. It also appears that in some deep-sea crustaceans the fluid excreted from the renal organs gives out a phosphorescent light. In another kind

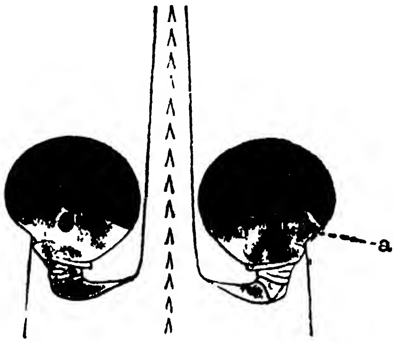


Fig. 1299.—Large Eyes of a Deep Sea Prawn (*Parapandalus spinipes*), enlarged. *a*, Accessory eye (?) or luminous organ (?).

Fig. 1300.—A Blind Deep-Sea Shrimp (*Prionocrangon ommatosteres*)

of Prawn (*Parapandalus spinipes*, fig. 1299) there is what looks like a small accessory eye near the big one. If, however, this is really a luminous organ, as some think, the prawn provides its own eyes with light.

To illustrate blind crustaceans we may take one of the Shrimps (*Prionocrangon ommatosteres*, fig. 1300), which is absolutely destitute of eyes.

Fig. 1301.—Group of Deep Sea Animals. In foreground—a Sea Cucumber on left, and a Coral (*Lophohelia*) on right. At back—Venus Flower Basket (*Euplectella*) on right, two Sea Lilies (*Rhizocrinus* and *Pentacrinus*) in centre, and on left. In the middle—a Pelican Fish (*Saccopharynx pelecanoides*).

The Stopper-Fisted Hermit-Crabs (*Pylocheles*) of the Indian Ocean and Caribbean Sea do not possess the twisted tails of our common native species, which live in cast-off snail-shells, nor is one of the pincers much larger than the other. These particular hermits are in all respects symmetrical, in adaptation

to their dwellings, which consist of water-logged joints of mangrove or bamboo. The large pincers act as a front-door, but a loophole is left between them to serve as a means of observation.

Certain kinds of crustacean grow to a very much larger size in the deep sea than elsewhere. Among the Slaters (*Isopoda*), for example, of which the terrestrial wood-lice are the most familar types, we find one species (*Bathynomus giganteus*) which is a foot long.

Hedgehog-Skinned Animals (*Echinodermata*) *of the Deep Sea.*—Star-Fishes, Brittle-Stars, and Sea-Urchins are all abun-

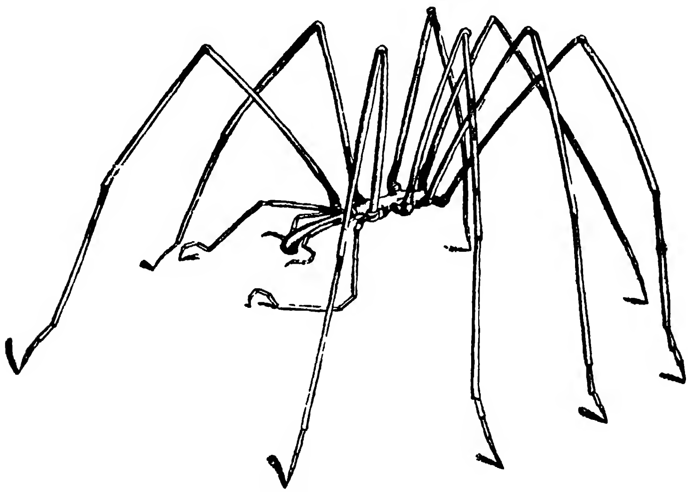


Fig. 1302.—Deep-Sea Pycnogonid (*Colossendeis*)

dantly represented in the abyss, while the beautiful Sea-Lilies (*Crinoidea*, fig. 1301), the representatives of a once dominant group, are found only in this zone. To this too are restricted the Elasipods, remarkable and apparently primitive types of the Sea-Cucumbers (*Holothuroidea*). They have a flattened under surface, and creep about like slugs on the soft deposits which cover the sea-floor (fig. 1301).

Abysmal Sea-"Spiders" (*Pycnogonida*).—These curious jointed-limbed animals, which in the Neritic zone are represented by comparatively small forms, attain relatively colossal proportions in the abyss. One of them (*Colossendeis*) is represented in fig. 1302.

Deep-Sea Corals (*Anthozoa*) *and Sponges* (*Porifera*).—Some

very beautiful Corals and Sponges are found in the deep sea. Some of the latter resemble elegant vases in shape, with walls supported by glassy threads interwoven like lace (fig. 1301). Others are moored in the soft deposits of the sea-floor by long bundles of slender spicules of similar nature.

PELAGIC ZONE—SURFACE LIFE

It will here be convenient to consider separately animals which are powerful swimmers (Nekton) and those which float or drift (Plankton).

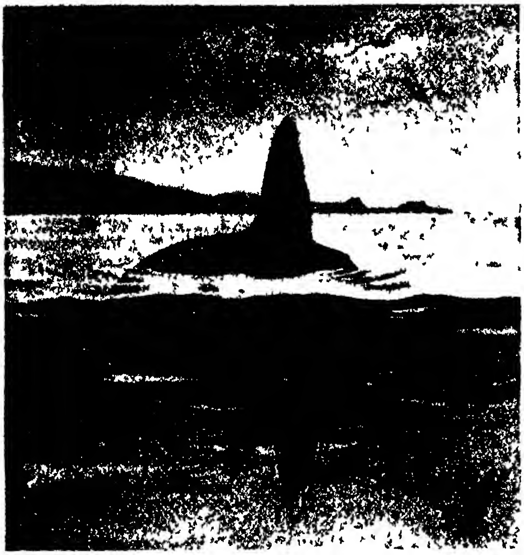


Fig. 1303.—Sun-Fish (*Orthagoriscus mola*)

Pelagic Nekton.—Among Mammals we find that the Pinnipede Carnivores (see p. 436) spend more or less of their time in this zone, to which they partly belong. More purely pelagic, and altogether independent of the land, are Whales and their allies (*Cetacea*). There are also Birds which are pelagic, notably the Albatross (*Diomedea exulans*) and the Tropic Birds (*Phaëthon*); while the Sea-Snakes (*Hydrophinæ*) of the Indian Ocean and part of the Pacific belong here in the main. A number of Fishes are chiefly met with in the open sea, among them being the Blue Shark (*Carcharias glaucus*) and the Rondeletian Shark (*Carcharodon Rondeletii*). The Flying-Fish (*Exocœtus volitans*) and its enemy the Bonito (*Albicore bonito*) are also pelagic, and so is the remarkably-shaped Sun-Fish (*Orthagoriscus mola*, fig. 1303). Many of the best swimmers among the Cuttle-Fishes and Squids are also found at or near the surface of the sea, far away from land.

Pelagic Plankton.—The floating and drifting population of the sea possess a number of common characteristics related to their mode of life. They are typically translucent or transparent, a feature due to the large proportion of water in their tissues. By making some of them more or less difficult to see, this may serve to some extent as a means of protection (see vol. ii, p. 278), and by reducing the density of their bodies it must certainly

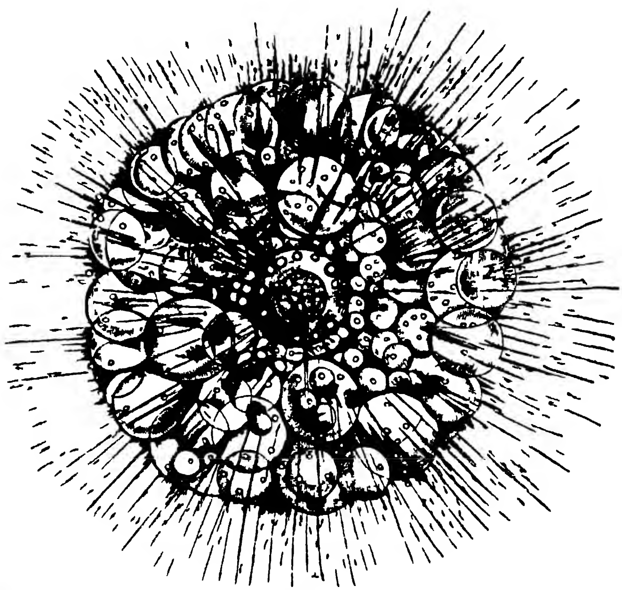


Fig. 1304.—A Ray Animalcule (*Thalassicolla pelagica*) with bubbly protoplasm, much enlarged

render floating a comparatively easy matter. The latter purpose is also promoted by arrangements of other kind. In many of the minute crustaceans and crustacean larvæ, for example, there are numerous spines and hairs which must reduce the tendency to sink. Oil-globules are of common occurrence, both in adult animals and in some floating eggs, such as those of fishes. And there may also be gas-receptacles for buoying up the body. In some of the Animalcules, for example, the living substance (protoplasm) of the animal is of "bubbly" consistency, owing to the presence of minute spaces filled with liquid, or even gas (fig. 1304). In many of the Compound Jelly-Fishes (*Siphonophora*) there is a gas filled float at the upper end of the colony,

and sometimes (*Velella*, fig. 1305) a crest projecting from this may almost be said to serve as a sail.

It must not be supposed, however, that plankton animals are always found at the surface, for, on the contrary, they are able to withdraw themselves from it to a greater or less depth, and thus avoid the damaging effects of a rough sea or an excess of temperature. Our ignorance is at present too great to enable us to explain the reasons for all the upward or downward movements which constantly go on, sometimes in a curious periodic manner. As Hickson says (in *The Story of Life in the Seas*,

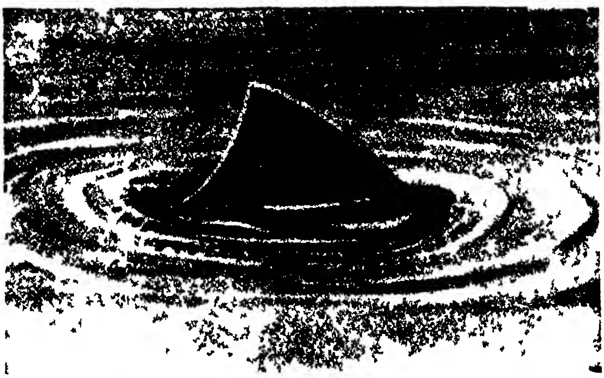


Fig 1305.—Velella

a little book which is heartily commended to the attention of readers) —"The fact is, that the conditions of life in the surface waters are so complicated that it is extremely difficult for us to accurately estimate the balance of the forces which act upon these organisms. The direct heat of the sun, the light of both the sun and the moon, the tranquillity or roughness of the sea, the conditions of the tides and winds which cause changes in the surface temperature of the water, independently of the direct heat of the sun, all influence the delicate tissues of which these animals' bodies are composed, and cause them to change their position." Phosphorescence is another common property of plankton animals, and its meaning is in many cases difficult to understand. Planktons are of very various character Some contain animals of many different species, others consist of a single form of life.

Vertebrates (*Vertebrata*) *of the Plankton.*—Among Fishes (*Pisces*) occasion has already been taken to note (see vol. iii,

p. 425) that a great many species lay floating eggs, and these, together with the transparent larvæ that hatch out of them, belong to the plankton fauna. Primitive Vertebrates (*Protochordata*) are abundantly represented by certain Sea-Squirts or Ascidians (*Urochorda*), including some little tadpole-shaped forms (*Appendicularia*, &c.), Barrel Ascidians (*Doliolum*), Salps (*Salpa*), and Fire-Cylinders (*Pyrosoma*), all of which have received notice

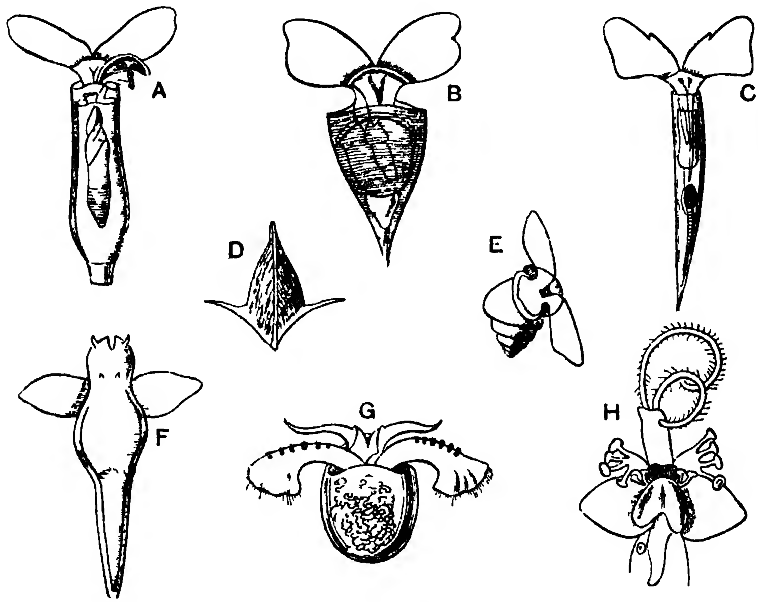


Fig 1306 Wing Footed Snails (*Pteropoda*) A Cuvierina B, Clio C, Creseis, D, shell of Cleodora E, Limacina F, Clione G, Halopsyche H, front part of Pneumoderma, with hook bearing tubes and groups of stalked suckers, securing prey A–E, Shell bearing forms F–H shell less forms

in earlier sections (see vol. i, p. 299; vol. iii, pp. 38 and 422; an p. 106 of present volume).

Plankton Molluscs (*Mollusca*).—The beautiful Violet-Sna (*Ianthina*), with its egg-raft, belongs here, also the members c the remarkable and diversified group of Fin-Footed Snails (*Hetero poda*), and a curious little Sea-Slug (*Phyllirhoe*), which is flattene from side to side (see vol. iii, pp. 34 and 36). Far mo characteristic than these, however, are the little Wing-Foot Snails (*Pteropoda*, fig. 1306), which are often found associat in vast shoals, affording an important contribution to the bill fare of animals so large as Whales.

The larvæ of numerous Molluscs simply swarm in the surface waters of the sea.

Plankton Insects (*Insecta*).—Although Insects are essentially land-forms, a few Bugs (e.g. *Halobates*) live on the surface of the open sea.

Plankton Crustaceans (*Crustacea*).—Many members of this group, and innumerable crustacean larvæ, are among the most important plankton animals. Some, as the Swimming-Crabs, may be of fair size, but by far the most dominant order is that of the Fork-Footed Crustaceans (*Copepoda*, fig. 1307), which are of great economic importance, because they constitute the staple diet of Herrings and some other valuable food-fishes (see p. 283).

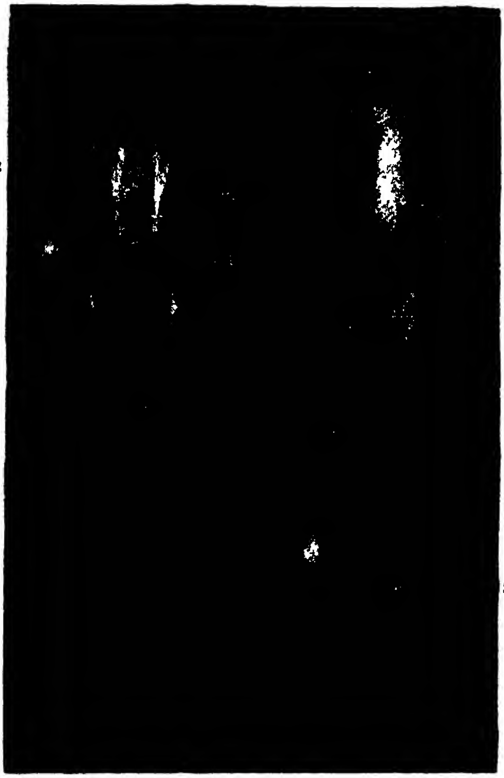


Fig. 1307.—Fork-Footed Crustaceans (*Copepoda*) with well-developed limbs. 1, Oncæa venusta. 2, Copilia vitrea. 3, Calocalanus pavo.

Plankton Annelids (*Annelida*).—Some members of this group are specially adapted to a life in the surface waters, and one remarkable example (*Tomopteris*) has elsewhere been described (see vol. iii, p. 22).

Plankton Echinoderms (*Echinodermata*).—The curious larvæ of all sorts of Echinoderms are abundantly found in plankton at certain times of the year, but the adult members of the group seem little suited for this kind of life. A kind of Sea-Cucumber (*Pelagothuria*), however, has acquired the necessary adaptations for the purpose (see vol. iii, p. 24).

Nemertine Worms (*Nemertea*) *of the Plankton.*—The larvæ

of these curious Worms, like those of the last-named group, are well represented in the surface waters of the sea, and some adult Nemertines have given up creeping and taken to a pelagic life. One of the most remarkable (*Pelagonemertes*) is represented in fig. 1308.

Plankton Thread-Worms (*Nemathelmia*). — Among the com-

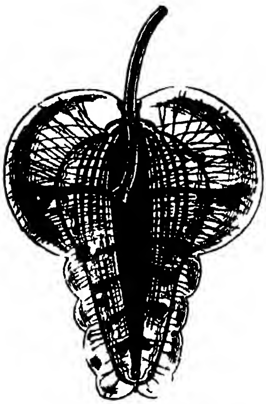


Fig 1308 —Pelagic Nemertine Worm (*Pelagonemertes*), reduced

Fig 1309 —Night Light Animalcules (*Noctiluca*), enlarged

monest inhabitants of the surface waters are the curious little fish-shaped Arrow-Worms (*Sagitta*, *Spadella*, &c.), which constitute a special group (*Chætognatha*) that is generally supposed to be an outlying constituency of the Thread-Worms (see vol. iii, p. 21), though its affinities are doubtful.

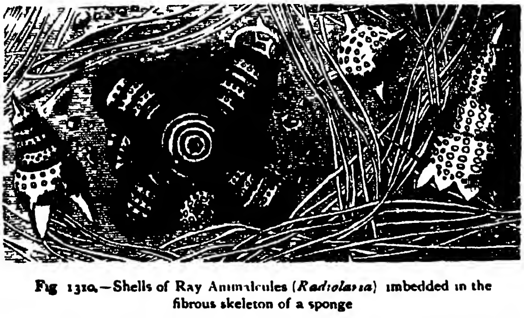


Fig 1310.—Shells of Ray Animalcules (*Radiolaria*) imbedded in the fibrous skeleton of a sponge

Plankton Zoophytes (*Cœlenterata*). —A bewildering variety of jelly-fishes, belonging to all sorts of groups, abound in the surface waters. Many of them have abandoned altogether the fixed zoophyte-stage that is found in the life-history of many such creatures (see vol. iii, p. 349). Perhaps the most interesting

among them are the Compound Jelly-Fishes (*Siphonophora*), which are floating colonies, often of very complicated nature, as the members of the colony are modified in many various ways in order to fit them for diverse functions (see p. 103).

Plankton Animalcules (*Protozoa*).—One very interesting form, the Night-Light Animalcule (*Noctiluca*, fig. 1309), is a common cause of the phosphorescent appearance of the sea around our

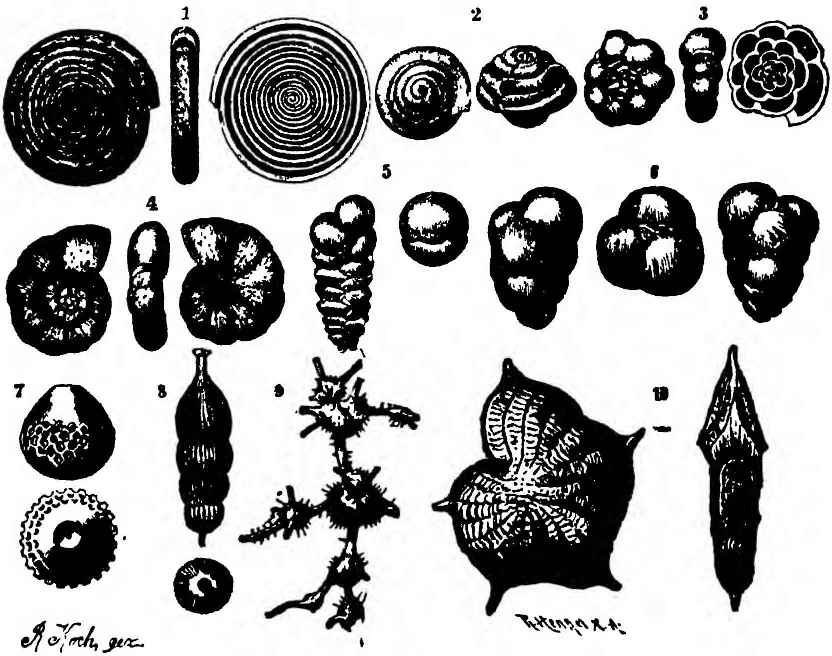


Fig 1311.—Group of Foraminifera. 1, Ammodiscus incertus; 2, A. charoides; 3, Trochammina coronata; 4, T. nitida, 5, Textularia agglutinans; 6, Verneuilina pygmæa; 7, Lagena seminuda. 8, Nodosaria scalaris; 9, Ramulina globulifera. 10, Polystomella imperatrix.

coasts. Two groups are very dominant in the plankton, the Ray-Animalcules (*Radiolaria*, fig. 1310) and the Forams (*Foraminifera*, fig. 1311). The former possess a flinty skeleton, often of great complexity and beauty, while the latter are provided with elegant calcareous shells of the most various shapes. Vast areas of the sea-floor are covered by soft "oozes", which are largely composed of the hard parts of deceased members of these two groups that are being continually rained down from the surface waters. There also appear to be some few species

of both groups that actually live on the floor of the abysmal zone.

Besides the typical plankton fauna which has just been briefly dealt with, the Pelagic zone is also inhabited by another assemblage of animals associated with various drifting objects, and particularly with the vast accumulations of sea-weeds that are found in the Sargasso Sea and elsewhere. Details would here be out of place, but it may be remarked that fixed forms of life, such as hydroid zoophytes, by attaching themselves to floating sea-weed, are enabled to maintain a foothold in the Pelagic zone. It is a matter of common knowledge that one of the most curious of fixed Crustaceans, the Ship-Barnacle (*Lepas*), is commonly found adhering to drifting objects.

The skins of Whales and Fishes also afford a home to quite a number of attached species, some of which are external parasites belonging to various groups. And many pelagic animals are also the unwilling hosts of numerous internal parasites, from which no zone affords escape.

Large bodies of fresh water may also be divided into zones, inhabited by characteristic faunas. The plankton of lakes is of particular interest, and also of some economic importance, as its population augments the food-supply available for freshwater fishes.

CHAPTER LXXVII

DISTRIBUTION IN TIME—THE GEOLOGICAL RECORD

If a large and complicated tree were submerged in water except the ends of some of its branches, these ends, projecting above the surface, would have the same sort of relationship to one another as existing groups of animals. To sketch the submerged tree on the evidence of the parts seen above water would prove a hopeless task, and to determine the mutual affinities of existing groups of animals without knowledge of their past history is also a difficult matter, though structure and development give many clues. Geology, however, furnishes us with a great deal of material from which to reconstruct the ancient life-history of the earth. It deals with periods of which the oldest date back to immensely remote times, if measured by the ordinary human standards of years and centuries, and the history of mankind occupies only the last page of the chronicle.

The Geological Record.—At the present time deposits of sand, mud, and limestone are being formed in the sea, in bodies of fresh water, and some other places, and these enclose the remains of dead animals, such as are well provided with hard parts standing the best chance of preservation. These deposits are arranged in successive layers, of which the uppermost are necessarily the youngest, and contain the remains of such animals as have most recently deceased. Examination of the hard framework of the land shows that a large part of it is made up of rocks, such as clay, slate, sandstone, and limestone, which are similarly arranged in layers, *i.e.* are *stratified*, each such layer being known as a *stratum* (fig. 1312). Imbedded in these strata are *fossils*, which are no other than the remains of animals (and plants) which once existed, or markings, *e.g.* footprints and other impressions, that prove the existence of certain forms of life at the time when the rocks containing them were formed. These strati-

fied rocks, the pages of the geological record, are the deposits formed in ancient seas and ancient lakes, or more rarely on old land-surfaces, in the same way that sand, or mud, or ooze is now accumulating on the floor of the existing ocean, in existing bodies of fresh water, or, it may be, on land. Such old deposits, however, have usually undergone more or less consolidation, and those which we now find above-water owe their present position to movements of elevation, such as are even yet in progress in certain parts of the world. But as these movements are generally extremely slow, they usually produce no obvious result in the brief span of a human lifetime. Remembering that a particular stratum or layer of rock (and of necessity its fossils) is older than those which rest upon it, and younger than those which underlie it, geologists have been able to arrange the different strata in their proper chronological sequence, and thus to construct a continuous geological record, often picturesquely known as the "record of the rocks". The fossils of the record obviously afford some idea, though necessarily an imperfect one, of the successive faunas of the globe for many millions of years, how many can only be conjectured. A hundred millions is a common estimate, based on many different kinds of evidence.

Fig. 1312.—Strata in Vertical Section

GEOLOGICAL PERIODS.—Without entering into details which may be found in any text-book of geology, it may be stated that the geological record can be divided into four great epochs, which are, beginning with the youngest:

KAINOZOIC EPOCH (Gk. *kainos*, recent; *zoē*, life).—Age of Birds and Mammals.
MESOZOIC EPOCH (Gk. *mesos*, middle; *zoē*).—Age of Reptiles.
PALÆOZOIC EPOCH (Gk. *palaios*, ancient; *zoē*).—Age of Amphibians, Fishes, and Invertebrates.
EOZOIC EPOCH (Gk. *eos*, dawn; *zoē*).—Age of Unknown Life.

The time represented by these four epochs is of very unequal length, but the Kainozoic, in which we live, has endured for a much shorter period than the Mesozoic, which in its turn was briefer than the Palæozoic, while possibly the Eozoic was longer than the other three put together. The entire geological record includes stratified rocks to a thickness of over 100,000 feet, a

sufficiently bulky volume in which to study the evolutionary history (phylogeny) of animal groups. As will be seen from the above indication of the types dominant in the successive epochs, there has been a successive progress from low to high, in conformity with the doctrine of evolution; but the record is very imperfect, and that part of it belonging to the Eozoic is made up of pages which so far have turned out to be practically blank. Many parts of the world, however, are as yet unexplored, so far as their geology is concerned, and during the last few decades the additions to our knowledge have been so great that much is to be hoped for in the future.

LIFE IN THE PALÆOZOIC EPOCH

That animal life existed long before the commencement of this epoch is sufficiently shown that in its earliest stage all the great groups of Backboneless Animals (Invertebrata), save those entirely devoid of hard parts capable of preservation, are represented, mostly by forms which we are able to classify with some approach to certainty. And before the epoch came to an end all the classes of Backboned Animals (Vertebrata), except Primitive Vertebrates (of the past history of which, owing to the soft nature of their bodies, we can never hope to learn much), Birds, and Mammals, had come into existence, as testified by numerous fossils.

PALÆOZOIC ANIMALCULES (PROTOZOA).—The Ray-Animalcules (*Radiolaria*) and Forams (*Foraminifera*) are here and there abundant. The flinty shells of the former make up hard siliceous bands (cherts) which were certainly deposited in very deep water, and correspond to the Radiolarian oozes which now cover parts of the ocean floor. Some of the limestones (*e.g.* the Fusulina limestone) belonging to that part of the epoch when our coal-fields were formed are made up mainly of the shells of Foraminifera, and these may be compared to the wide-spread foraminiferal oozes of the present day.

It may be remarked, in passing, that some of the rocks of the Eozoic epoch (in Brittany) contain the remains of Ray-Animalcules.

PALÆOZOIC ZOOPHYTES (CŒLENTERATA).—The variously-shaped colonial forms known as Graptolites (*Rhabdophora*, fig. 1313) are largely represented in some of the older Palæozoic rocks, and the

group died out entirely before the end of the epoch. They were very probably related to the existing Hydroid Zoophytes, and most of them belonged to the plankton of their time, and were most likely attached to drifting masses of sea-weed. In fact, Sargasso conditions were probably then more widely spread than now.

Corals were extremely abundant, and some of them were reef-builders, but they were mostly of a more primitive type than those now existing, and chiefly belonged to the extinct group of Four-Rayed Sea-Flowers (*Tetractinia* or *Rugosa*).

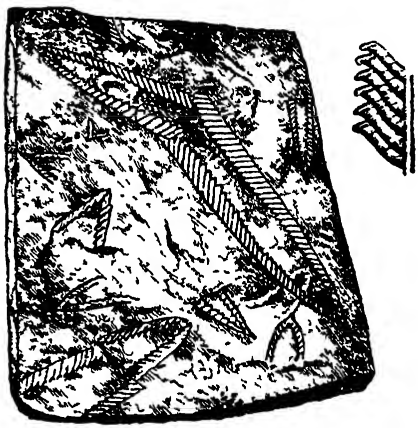


Fig 1313.—Forked Graptolites (*Didymograptus*) on the surface of a piece of rock. A small part of one is drawn to a larger scale.

PALÆOZOIC HEDGEHOG-SKINNED ANIMALS (ECHINODERMATA).—Sea-Lilies (*Crinoidea*), now a declining group, were extremely abundant, and some of the Palæozoic limestones are mainly composed of their remains. Two other classes of fixed Crinoids are limited to this epoch, and one of them (*Cystoidea*) is of particular interest, because it probably represents the stock from which all other echinoderm groups have been derived, directly or indirectly. The other order (*Blastoidea*) was a sterile side-branch. Star-Fishes (*Asteroidea*) and Brittle-Stars (*Ophiuroidea*) were both represented, and one of the former (*Palæodiscus*) possessed a biting apparatus like that of many Sea-Urchins. The class (*Echinoidea*) to which creatures of the last-named kind belong was represented by a number of primitive types, with more numerous plates than later species, and (on the evidence of Palæodiscus) it has been suggested that Sea-Urchins are descended from Star-Fishes.

PALÆOZOIC LAMP-SHELLS (BRACHIOPODA).—This group of greatly specialized worms, distinguished by the possession of a bivalve shell, at the present time contributes but little to the fauna of the sea. In the Palæozoic epoch it was extremely

dominant, and embraced a great variety of species, mostly belonging to extinct types. It is notable, however, that some of the lowlier forms which lived at the beginning of the period, *e.g.* the Tongue-Shells (*Lingula*, &c., fig. 1314), have persisted to the present day with but slight modification, so far as can be judged from the shell alone. That these and other "persistent types" should remain unmodified for vast periods of time has been brought forward as an argument against the doctrine of evolution. It is, on the contrary, what might be expected to sometimes occur in animals devoid of relatively complex adaptations to their surroundings. It was also at one time positively stated that Lamp-Shells, taken as a whole, afford no instance of modification on evolutionary lines. Of late years, however, thanks to the brilliant work of the American school of geologists, we know that the evidence afforded by this group is enough in itself to convince any candid naturalist that evolution has been the guiding principle in the animal world.

Fig. 1314.—A fossil Tongue-Shell (*Lingulella*), somewhat enlarged

PALÆOZOIC JOINTED-LIMBED ANIMALS (ARTHROPODA).—All the existing orders of *Crustaceans* (*Crustacea*) were represented

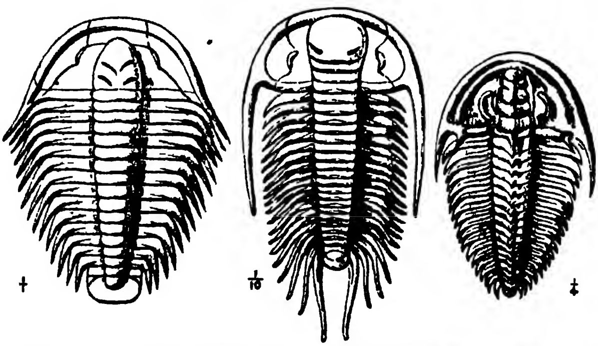


Fig. 1315.—Upper Surfaces of three Trilobites. Olenus (left), Paradoxides (centre), Olenellus (right). Actual size indicated by the fractions.

in the fauna of this epoch, except the Fork-footed Crustaceans (*Copepoda*), which are of too delicate a nature to be preserved as fossil, though they no doubt existed. It is noticeable that some of the more primitive types made their appearance very early, the contrary being true for the more specialized ones, such as creatures of the prawn and crab kind.

The curious *Trilobites* (*Trilobita*, fig. 1315), which constituted a closely allied class, were dominant in the older Palæozoic periods, but became entirely extinct before the end of the epoch. In these creatures the upper side of the body was covered by a firm investment divided into a head-shield, a varying number of thoracic segments, and a tail-shield. There was also, as a rule, a longitudinal division into three regions, and this is the origin of the name "trilobite". The numerous species exhibited a great range of characters, both as regards size, shape, and other features. The upper side of the head-shield often bore a pair of eyes, frequently large and facetted, but visual organs were sometimes entirely absent. Our knowledge of the under surface and limbs of trilobites was very incomplete till comparatively recently, partly on account of the delicacy of these parts, but now, chiefly owing to the investigations of American geologists on certain well-preserved species, many points relating to them have been elucidated. The head carried a pair of slender feelers, and there were numerous pairs of forked limbs used for crawling and swimming, while some of those in the region of the mouth acted as jaws (fig. 1316). Many of the stages in growth have been observed, and it may be said that trilobites which, when adult, are of simple structure, resemble the early stages of those which attain to greater complexity. This is precisely what the doctrine of evolution would lead us to expect. It may be added that many trilobites were able to roll up like hedgehogs, and this was no doubt a means of protection.

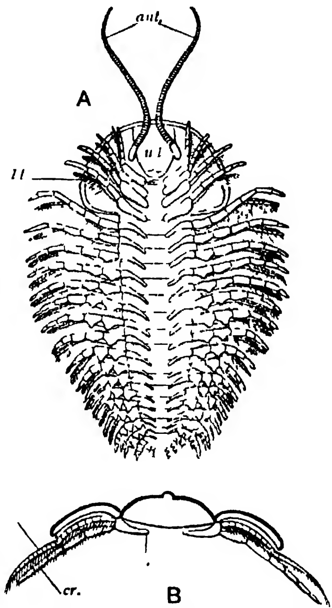


Fig. 1316.—A, Under side of a Trilobite (*Triarthrus*), restored, showing the numerous jointed limbs. *ant*, antennæ; *u l*, upper lip; *l l*, lower lip. B, Diagrammatic cross section through same, showing limb-regions. *j*, Projection serving as a jaw; *sw* and *cr*, swimming and creeping branches.

Appearing rather later in time than the Trilobites, which they to some extent supplanted, we find *Eurypterids* (e.g. *Pterygotus*, fig. 1317), some of which attained a length of about 5 feet. They died out before the end of the epoch, and appear to have

been related to the Crustaceans. The *King-Crabs* (*Xiphosura*), now represented by a single genus (*Limulus*), first made their appearance in Palæozoic times. They are sometimes included with the Eurypterids in a special group (*Merostomata*).

Centipedes and *Millipedes* (*Myriapoda*) were represented by several palæozoic forms with somewhat primitive characters, while among *Spider-like Animals* (*Arachnida*) there were Scorpions, which appeared comparatively early, Whip-Scorpions, and Spiders, besides representatives (e.g. *Eophrynus*, fig. 1318) of

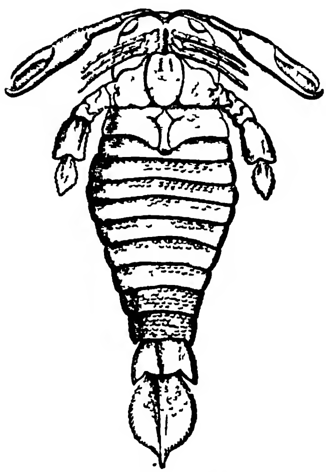


Fig. 1317.—A Eurypterid (*Pterygotus*), much reduced.

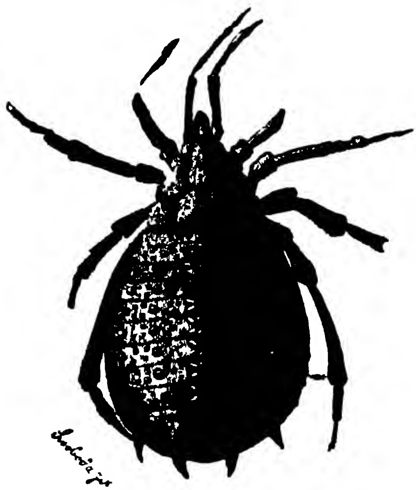


Fig. 1318.—An extinct Arachnid (*Eophrynus*).

an order limited to the epoch. Four orders of *Insects* (*Insecta*) had palæozoic representatives, *i.e.* Primitive Wingless Insects (*Aptera*), Straight-Wings (*Orthoptera*), Net-Wings (*Neuroptera*), and Bugs (*Hemiptera*). Some of them were of considerable size, and it is by no means certain that the older types really belonged to existing orders.

PALÆOZOIC MOLLUSCS (MOLLUSCA).—Among *Head-Footed Molluscs* (*Cephalopoda*) now existing, only the Pearly Nautilus (*Nautilus*) possesses an external shell, of which the part not occupied by the animal is divided by partitions into a series of gas-filled chambers. But in the palæozoic rocks we find the remains of a great many species thus characterized. Their shells were straight, curved, open spirals, or closed spirals, like that of Nautilus, which dates back to the middle of the epoch. It seems

probable that the straight-chambered shell was first evolved, and that this gradually underwent a process of coiling up, as a means of facilitating locomotion.

Marine *Snails* (*Gastropoda*) are abundantly represented among the palæozoic fossils, and it may be said generally that they belonged to the more primitive families, and were mostly of vegetarian habit. We also know that Land-Snails existed. The *Tusk-Shells* (*Scaphopoda*) date back to this epoch, and *Bivalves* (*Lamellibranchia*), the older ones of primitive type, were abundant. *Primitive Molluscs* (*Amphineura*) were represented by Mail-Shells (*Chiton*, &c.) of various kind.

Palæozoic Fishes (Pisces).—There is no clear proof of the existence of fishes in the earlier rocks of the epoch, but later on they became abundant. The teeth and spines of *Sharks*, &c. (*Elasmobranchii*), are common fossils, and the armour-plated marine ancestors of *Ganoids* (*Ganoidei*) were abundantly represented, as also forms in all probability ancestral to the *Lung-Fishes* (*Dipnoi*). Many palæozoic fishes also belonged to orders that are now extinct. Some of the oldest of the fish-like forms, distinguished by a covering of shelly plates on the front part of the body, also by the absence of lower jaws and paired fins, were probably not really fishes at all, and have been placed in a special group (*Ostracodermata*, fig. 1319) of lower rank.

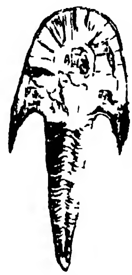


Fig 1319.—An Ostracoderm (Cephalaspis), much reduced

Palæozoic Amphibians (Amphibia).—These are represented in the second half of the epoch by numerous species, all belonging to an extinct order (*Stegocephala*), distinguished by the possession of skins which were more or less armour-plated, especially on the head. While some of these creatures were small, others attained considerable dimensions. The footprints of some of them have been preserved. The chief interest attaching to the order lies in the fact that it was probably ancestral to Reptiles. It is also worth while noting that some few members of the order (e.g. *Dolichosoma*) were limbless and snake-like, suggesting a comparison with the recent Cæcilians (*Gymnophiona*), a widely distributed and in some respects primitive group, *e.g.* in the possession of little bony plates in the skin.

Palæozoic Reptiles (Reptilia).—A few fossil types from

the last stage in the Palæozoic epoch, formerly placed in the Stegocephala, are now referred to an extinct order of Reptiles (*Prorcptilia*), which furnishes the nearest approach to the original reptilian stock. A further stage in evolution was represented by a second order (*Rhynchocephala*), from which the remaining groups of reptiles have probably sprung. There is a single existing species, the Tuatara (*Hatteria punctata*) of New Zealand. There were some other palæozoic reptiles, but these will be mentioned in dealing with the succeeding epoch.

LIFE IN THE MESOZOIC EPOCH

The animals of this epoch approached more nearly those of the present day than did their palæozoic predecessors. They included, however, a number of remarkable extinct groups, some of which were extremely dominant, while other classes, *e.g.* Birds and Mammals, which now play leading parts, were but feebly represented.

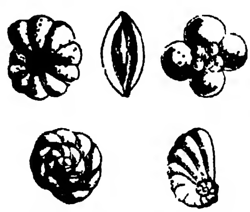


Fig. 1320.—Foraminifera from the Chalk.

MESOZOIC ANIMALCULES (PROTOZOA). The familiar chalk, which makes up the "white cliffs of Albion", and ranges east far into Asia, was deposited in the later part of the epoch. It is very largely made up of the remains of Foraminifera (fig. 1320), and before compacted and upheaved must have borne a close resemblance to the foraminiferal oozes which are now spread over a large part of the ocean floor.

MESOZOIC SPONGES (PORIFERA).—During the chalk period a large number of Sponges possessed of siliceous skeletons existed in the moderately deep sea, and it is their remains which chiefly furnished material for the large flint nodules that abound in part of the chalk, and which have a very particular interest for students of the evolution of human civilization, since from them many of the stone implements and weapons of prehistoric European races were fashioned.

MESOZOIC ZOOPHYTES (CŒLENTERATA).—Corals were extremely abundant during the epoch, and many of them were reef-builders. They belonged to the same great group (*Hexactinia*) that includes the most typical recent forms, being, like them, distinguished by a six-rayed symmetry.

MESOZOIC HEDGEHOG-SKINNED ANIMALS (ECHINODERMATA).—Sea-Lilies (*Crinoidea*) were far less dominant than during the Palæozoic epoch, and were represented by types of different kind, some of them (e.g. *Pentacrinus*) being closely allied to forms now living in the deep sea. Feather-Stars, belonging to the same class, but distinguished by the fact that when adult they abandon their stalks and take to a free life, first made their appearance during this epoch.

Ordinary Star-Fishes (*Asteroidea*) and Brittle-Stars (*Ophiuroidea*) were of increasing importance, and very numerous Sea-Urchins (*Echinoidea*) existed, many of them resembling recent forms, and differing greatly from the primitive palæozoic types.

MESOZOIC LAMP-SHELLS (BRACHIOPODA).—These lost their dominance during this epoch, and the most important species belonged to genera which are represented at the present day (e.g. *Terebratula* and *Rhynchonella*).

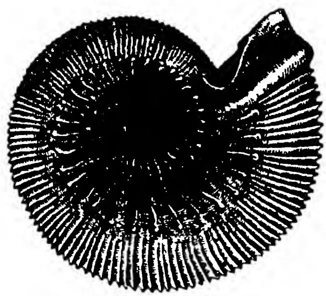


Fig. 1321.—Shell of an Ammonite (reduced)

MESOZOIC JOINTED-LIMBED ANIMALS (ARTHROPODA).—The Trilobites and Eurypterids of the Palæozoic epoch were entirely unrepresented, but undoubted *Crustaceans* (*Crustacea*) were common. These included numerous species belonging to the highest order (*Decapoda*), and more or less resembling the Lobsters, Prawns, Shrimps, and Crabs of the present day.

Among the air-breathing forms *Insects* (*Insecta*) were gradually acquiring a dominant position. Of orders for the first time represented may be mentioned Beetles (*Coleoptera*), Flies (*Diptera*), and Membrane-Wings (*Hymenoptera*). Ants are the most ancient members of the last order, so far as the evidence goes.

MESOZOIC MOLLUSCS (MOLLUSCA).—*Head-Footed Molluscs* (*Cephalopoda*) took a leading place in the marine fauna. Two important types, *i.e.* Ammonites and Belemnites, were practically limited to the epoch. The former (fig. 1321) possessed spiral chambered shells, with the turns in one plane, and the edges of the partitions between the successive chambers elaborately folded. Towards the end of the epoch, however, we find more or less

unrolled species (fig. 1322), some even that were perfectly straight. Such types may perhaps be regarded as unsuccessful attempts at adaptation to changing surroundings. The Belemnites (fig. 1323) possessed internal shells, and in this and some other respects, *e.g.* the possession of an ink-bag, resembled recent Cuttle-Fishes, though they belonged to a distinct group. Cuttle-Fishes and Squids, which are now dominant members of their class, were feebly represented in Mesozoic times, but as they alone proved able, mainly by acquiring a rapid mode of swimming, to fully adapt themselves to their environment, they finally succeeded in almost entirely supplanting the more ancient types related to them.

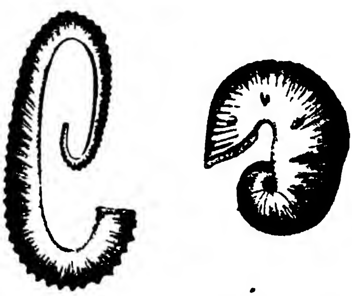


Fig. 1322.—Uncoiled Cephalopods related to Ammonites: *Hamites* left, *Scaphites* right, reduced.

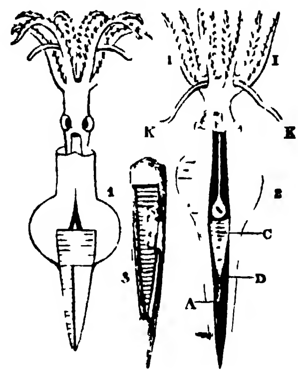


Fig. 1323.—Belemnites (reduced). 1 and 2, Restorations. A D C, internal shell; F, funnel; I I, short arms; K K, long arms; N, ink bag; 3, shell.

Although many of the primitive palæozoic types of marine *Snails* (*Gastropoda*) were able to maintain their foothold during this epoch, the leading place was taken by specialized carnivorous forms, which became more numerous and varied as time went on.

Bivalves (*Lamellibranchia*) played a much more important part than in the preceding epoch, many new and more advanced types coming into existence. The families now represented by Oysters, Cockles, Mussels, and Razor-Shells, among many others, first made their appearance.

MESOZOIC FISHES (PISCES).—The last marine representatives of existing *Lung-Fishes* (*Dipnoi*) existed in the earlier part of the epoch, and some of the fossil teeth are so like those of the Queensland Lung-Fish (*Ceratodus*) as to suggest a close relationship with that form. There were many mesozoic *Sharks*, &c. (*Elasmobranchii*), and we can trace the gradual specialization of

their flattened relatives, the Skates and Rays. *Ganoids* (*Ganoidei*) abounded, and some of them appear to have been ancestral to Sturgeons.

Ordinary Bony Fishes (*Teleostei*) are the dominant members of their class at the present day, and date back to the later stages of the Mesozoic epoch. Some of the older types, less well adapted than they to an aquatic life, have gradually declined since the time of their first appearance.

MESOSOIC AMPHIBIANS (AMPHIBIA).—The armoured Amphibians (*Stegocephala*) of the palæozoic lived on into the earlier part of this epoch, to which belonged the largest known member of the order (*Mastodonsaurus*), the head of which was about four feet long The teeth and footprints (fig. 1324) of this and related forms were characteristic, and have been known to geologists for a comparatively long time. The former were conical, and exhibit in cross-section very elaborate folds of enamel, which suggested the name of "Labyrinthodon" (*i.e.* labyrinth tooth). The footprints look something like the impressions of clumsy hands, hence the old name "Cheirotherium" (*i.e.* hand-animal).

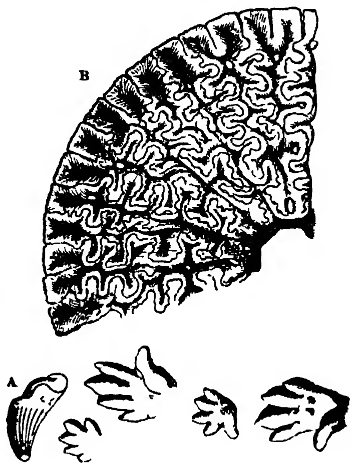


Fig. 1324. -Labyrinthodon A, Tooth and footprints (reduced). B, part of cross-section of tooth enlarged)

MESOZOIC REPTILES (REPTILIA).—The ancient order (*Rhynchocephala*), of which the Tuatara (*Hatteria*) is the only living representative, includes a number of species which were widely distributed in the early part of this epoch. Some of them were as much as 6 feet in length.

One of the most interesting extinct orders of the class, the *Varied-Toothed Reptiles* (*Anomodontia*) includes characteristic land-forms which lived during the later part of the Palæozoic epoch and the earlier part of the Mesozoic. The interest attaching to them lies in the fact that in certain respects they were intermediate in structure between the Armoured Amphibians and the lower Mammals, so that they probably represent the stock from which the last class has taken origin. Among mesozoic types may

be mentioned the following:—Pareiasaurus (fig. 1325), a particularly clumsy-looking creature some 8 feet long and between 2 and 3 feet high; Cynognathus, with skull and teeth not unlike those of a dog; and Dicynodon, possessing large tusk-like upper canines.

The five extinct orders of Reptiles now to be mentioned were

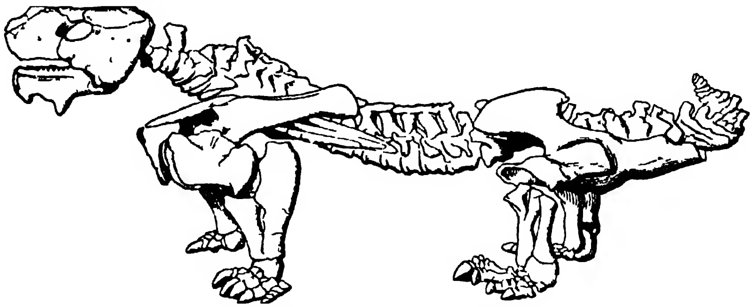


Fig. 1325.—Pareiasaurus (much reduced)

represented by a large number of forms peculiar to the epoch, and severally adapted to the most various conditions of life, in the sea, on the land, and even in the air.

Fish-Lizards (*Ichthyosauria*).—These were large rapacious marine forms, something like whales in shape, and with paddle-like limbs (fig. 1326).. Judging from their enormous eyes they

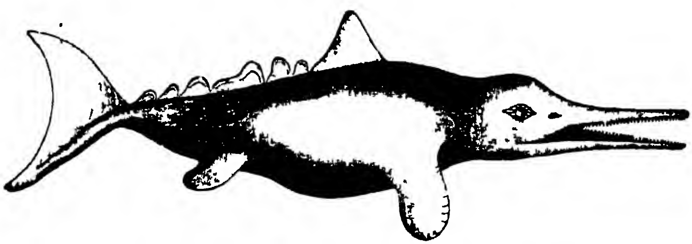


Fig. 1326.—Restoration of Fish Lizard (*Ichthyosaurus*), much reduced

were of nocturnal habit. Another interesting feature was the unsymmetrical tail, with the larger lobe below. The shape of this would facilitate return to the surface after diving (see vol. iii, p. 289).

Sea-Lizards (*Plesiosauria*).—These also were marine reptiles with large paddles, and the most familiar types (e.g. *Plesiosaurus* fig. 1327) possessed a long almost swan-like neck. The earlier members of the order appear only to have been semi-aquatic.

Sea-Serpents (*Pythonomorpha*).—During the later part of the epoch the marine reptiles belonging to the last two orders diminished in numbers and importance. They were to some extent replaced by the snake-shaped creatures of the present group, with small short paddles. Some of the largest forms (*Mosasaurus*) seem to have been as much as 49 feet in length.

Terrible Reptiles or Dinosaurs (*Dinosauria*).—The members of this varied group were the dominant land-reptiles of the epoch, and were represented by a great variety of remarkable species. The Reptile-Footed Dinosaurs (*Sauropoda*) were herbivorous forms with hoof-bearing plantigrade extremities. Some of them attained a very large size, the most gigantic (*Atlantosaurus*) is even believed to have been as much as 115 feet long. The Beast-footed Dinosaurs (*Theropoda*) were of carnivorous habit, and distinguished by the great proportionate length of their hind-limbs, which suggests that hopping was their typical mode of locomotion. They included species of greatly differing size, from that of a cat to that of an elephant. The Armoured Dinosaurs (*Stegosauria*) were herbivorous creatures, and in the type-genus (*Stegosaurus*, fig. 1328), which included species some 28 feet long, the back was protected by a series of large flattened bony plates, passing into spines on the upper side of the tail. The head was of relatively small size, and the brain so tiny that the intelligence must have been small. The herbivorous Bird-Footed Dinosaurs (*Ornithopoda*) are so-called because the structure of their hind-limbs

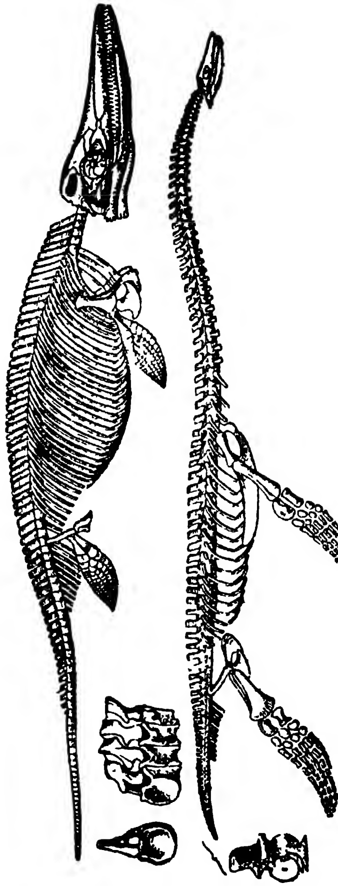


Fig 1327 Skeletons of Fish Lizard (*Ichthyosaurus*) and Sea-Lizard (*Plesiosaurus*), much reduced

presents some points of resemblance to birds, probably due to their having been adapted to the same kind of locomotion on

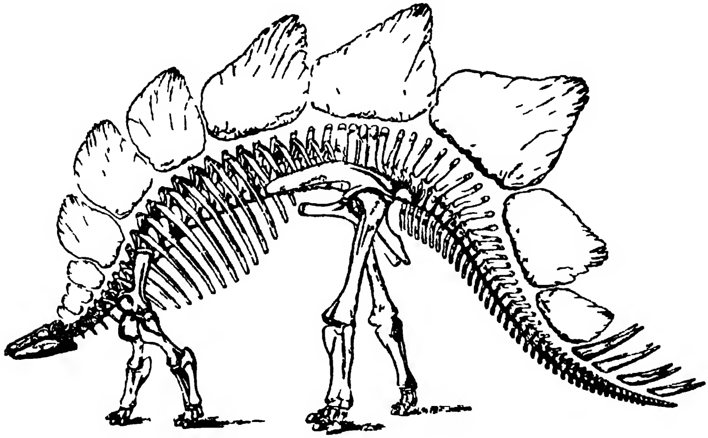


Fig 1328 —Stegosaurus (much reduced)

the ground. These limbs were relatively very long, and they were also digitigrade, *i e.* the animals possessing them walked on tiptoe. The best-known member of the group—(*Iguanodon*, fig 1329) inhabited England, Belgium, and Germany during the second half of the Mesozoic epoch, and the larger of the two known species was nearly 30 feet in length The Horned Dinosaurs (*Ceratopsia*), which were among the later forms of the epoch, included a remarkable herbivorous creature (*Triceratops*) over 20 feet in length, with three horns on the head, and a curious bony shield covering the neck.

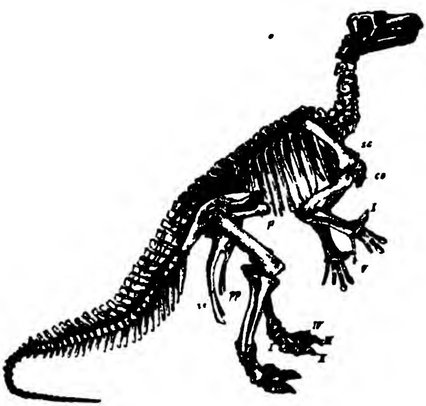


Fig 1329 —Iguanodon (much reduced) *sc* Scapula *co* coracoid i and v (in fore limb) thumb and little finger *p* pubis produced back into post pubis (*pp*) *is*, ischium i iv (in hind limb) 1st to 4th toes

Flying Reptiles (*Pterosauria*)—The organs of flight of these extraordinary animals have elsewhere been described (see vol iii, p. 308). Some were of small size, and of these the Pterodactyles (*Pterodactylus*,

fig. 1330) were short-tailed. But one of the later types (*Pteranodon*) was a toothless reptile with a spread of wing not far short of 20 feet.

Crocodiles (*Crocodilia*) and *Turtles* (*Chelonia*) were numerous during the Mesozoic epoch, and in the later part of it both *Lizards* (*Lacertilia*) and *Snakes* (*Ophidia*) are known to have existed.

MESOZOIC BIRDS (AVES).—The few mesozoic birds which have so far been discovered have certain characters, *e.g.* the possession of teeth, which suggest reptilian descent. In the oldest known form (*Archæopteryx*), which has elsewhere been described (see vol. iii, p. 296), the tail was long, and bore pairs of quill-feathers at regular intervals.

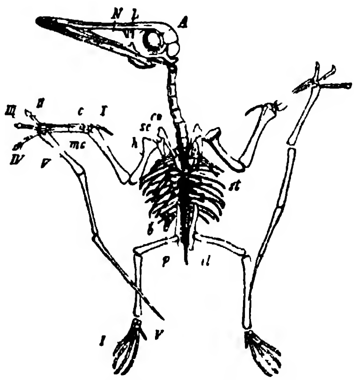


Fig 1330 - Pterodactyle *Pterodactylus*, reduced. A, Eye, L, lachrymal bone, *sc*, scapula, *co*, coracoid, *h*, humerus, *c*, carpus *mc*, metacarpus I-V (in fore-limb), thumb and fingers *st*, sternum *b*, abdominal ribs, *p*, pubis, *il*, ilium, I-V (in hind limb), toes

MESOZOIC MAMMALS (MAMMALIA).—That a certain number of small mammals lived during the Mesozoic epoch is known from the discovery of fossil lower jaws in several localities. Some of these suggest affinity with Egg-laying Mammals (*Monotremata*), while others probably belonged to small Pouched Mammals (*Marsupialia*). It has been suggested that Mammals evolved from some of the Varied-Toothed Reptiles (*Anomodontia*) on a land-area in the southern hemisphere, which there is some reason to believe once existed (see p. 411). Smith Woodward (in *Vertebrate Palæontology*) states that in Jurassic (*i.e.* mid-mesozoic) times—" . . . it is extremely probable that on some continent in that part of the globe the Anomodontia were gradually being transformed into Mammalia. At least, in the Jurassic formations both of Europe and North America there are occasional remains of small mammals as large as rats; and the most plausible explanation of these is, that they were accidental escapes from some other region with a more advanced fauna, just as are the rats and mice of the present day in the comparatively antique realm of Australia."

LIFE IN THE KAINOZOIC EPOCH

Even in the earlier stages of the Kainozoic epoch we find that the fauna had a comparatively modern aspect, and the later stages ultimately merge into the present. Among backboned land-animals Mammals and Birds were dominant, and it will be as well to confine our attention to a few interesting facts concerning these groups.

KAINOZOIC MAMMALS (MAMMALIA).—The fossil remains which have so far been examined enable us to trace the gradual evolution of the subdivisions of several mammalian orders, notably

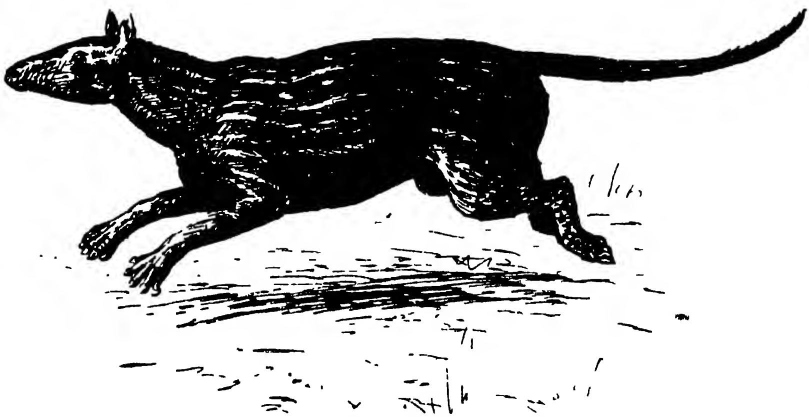


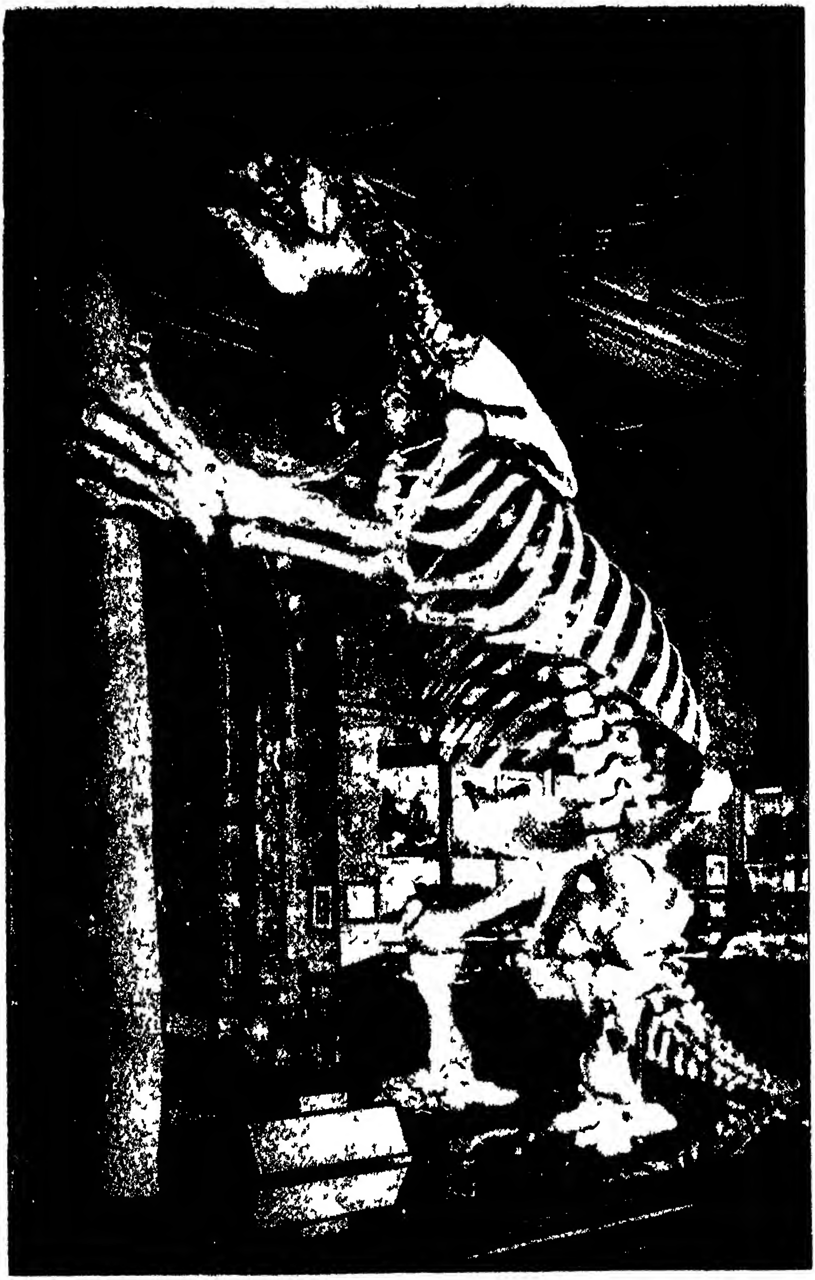
Fig. 1331.—Restoration of Phenacodus (reduced)

so as regards *Hoofed Mammals* (*Ungulata*) and *Flesh-Eaters* (*Carnivora*). In the earliest stage of the epoch we find the ancestors of the hoofed forms represented by small primitive swamp-dwellers, constituting an extinct group (*Condylarthra*), of which a well-known type (*Phenacodus*) is represented in figs. 1331 and 1332. By increasing complications of structure, affecting limbs, teeth, brain, &c., the various odd-toed and even-toed ungulates have sprung from creatures of the kind, as also *Conies* (*Hyracoidea*), and, most probably, *Elephants* (*Proboscidea*). The nature of some of the specializations which took place have been briefly explained in a previous section (see vol. iii, p. 137).

What is true for Hoofed Mammals as regards one primitive group is also true for Flesh-Eaters with reference to another such group (*Creodonta*). Indeed there is not a great deal

AN EXTINCT GROUND-SLOTH (*Megatherium*)

It is a remarkable fact that certain groups of land-animals were in part represented, in comparatively late geological times, by gigantic forms which have since become extinct. This is the case, for example, with the Mammals poor in Teeth (*Edentata*), to which belongs the South American Ground-Sloth (*Megatherium*) represented in the plate, which is taken from a photograph of a restoration in the British Museum. In size it was nearly as large as an elephant, and is believed to have fed on leaves, as do the relatively insignificant Sloths which now live in the trees of the South American forests. The plate represents the Ground-Sloth in the position it assumed for the purpose of pulling down branches, or uprooting small trees, in order to obtain its food.



EXTINCT SOUTH AMERICAN GROUND-SLOTH (MEGATHERIUM)

of difference between the early kainozoic ancestors of Ungulates and Carnivores, both of which undoubtedly sprang from the same mesozoic stock, though this is as yet unknown. In similar fashion we find that the lines of descent of recent *Insect-Eaters* (*Insectivora*), *Lemurs* (*Lemuroidea*), and *Monkeys* (*Primates*) converge as we trace them back to the beginning of the epoch. The branches of the genealogical tree of mammals corresponding to the last two groups actually meet, and on this account some experts would place the Lemurs in the same order as Monkeys (*Primates*). We further find that the lines of descent of Insectivores, Lemurs, and Monkeys converge towards those of the Ungulates and Carnivores, and this appears to be also true for the *Mammals Poor in Teeth* (*Edentata*). Some day, perhaps, we may be able to trace back all these six orders, together with Conies and Elephants, to common mesozoic ancestors.

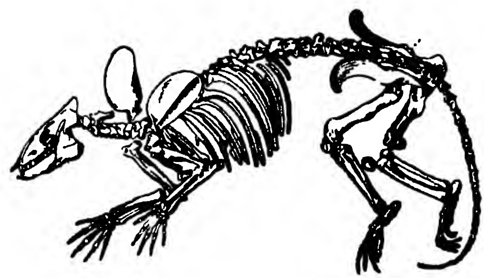


Fig 1332—Skeleton of Phenacodus (reduced)

Whales, &c. (*Cetacea*), *Sea-Cows* (*Sirenia*), *Gnawers* (*Rodentia*), and *Bats* (*Chiroptera*) seem to have acquired their typical characters before the Kainozoic epoch began, and we are not yet able to trace them back to the main line of mammalian descent. The two first groups, and creatures of the seal kind, replaced the marine reptiles of Mesozoic time in the life of the sea, and the Flying Reptiles proved unable to maintain their supremacy against the competition of Bats and Birds.

In the later part of the Kainozoic epoch certain orders of mammals were represented by relatively gigantic forms. A good instance of this is afforded by certain extinct American representatives of the *Mammals Poor in Teeth* (*Edentata*). At this time South America and the southern part of the sister continent were inhabited by huge Ground-Sloths, of which one typical form (*Megatherium*) was at least as large as an elephant. It and its allies combined some of the structural features of existing Sloths and American Ant-Eaters. That so large an animal as the one mentioned was not a climber is sufficiently obvious.

It is supposed to have been a leaf-eater, pulling off branches, or even uprooting small trees. A related form (*Mylodon*), which attained the size of a rhinoceros, possessed an external skeleton consisting of small bony plates imbedded in the skin. Remains of the skin, &c., of an allied type (*Neomylodon*) were not long since discovered in a South American cave, and in so fresh a state as to warrant a belief in the animal's recent extinction, while some naturalists, partly on the strength of native traditions, believe (or at any rate hope) that the creature still lives in the desert regions of Patagonia. Gigantic Armadilloes, of which one type (*Glyptodon*) was about 16 feet in length, inhabited America in comparatively late Kainozoic times.

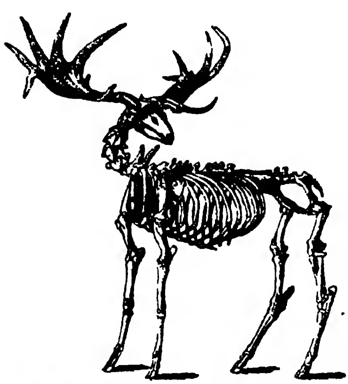


Fig 1333 —Irish Elk (*Cervus Hibernicus*), much reduced

Turning to Australia, we find that some of the immediate predecessors of the *Pouched Mammals* (*Marsupialia*) of that continent attained large dimensions. The skull of the Pouched "Lion" (*Thylacoleo*), a form related to the existing Phalangers, was about 9 inches long. Its name is rather unfortunate, for it was probably of vegetarian habit. Very much larger than this was a gigantic animal (*Diprotodon*) related both to the Phalangers and Kangaroos, for it was about as large as a rhinoceros, its skull alone being over 3 feet in length. Its limbs were adapted for walking.

Three large extinct Mammals have a special interest as being contemporaneous with prehistoric Man in Western Europe, including Britain. One was the Irish "Elk" (*Cervus Hibernicus*, fig. 1333), remains of which are not uncommon in the peat-bogs of Ireland. The female possessed no antlers, but the male was well-endowed in this respect, for in him these weapons sometimes had a spread of about 10 feet. The Sabre-Toothed Tiger (*Machairodus*) belonged to a group of Flesh-Eaters now extinct, and possessed enormous upper tusks, which are responsible for its name. The lower tusks were quite small. It seems that the huge weapons of creatures of the kind were too well developed to be of much use, probably indeed acting as encum-

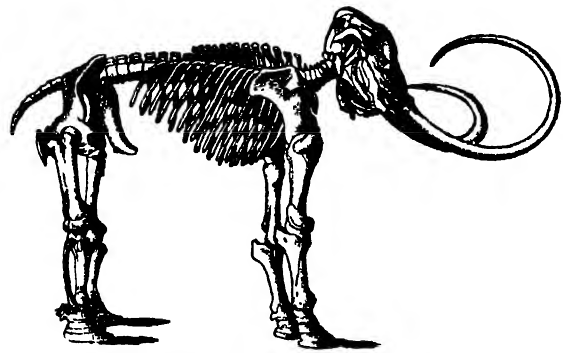


Fig. 1334.—Mammoth (*Elephas primigenius*), much reduced

brances which in the end brought about extinction. Here, as in many other cases, over-specialization proved fatal. The last extinct Mammal to be mentioned is the Mammoth (*Elephas primigenius*, fig. 1334), a sort of Elephant which had a very wide geographical range in the northern hemisphere, especially in the colder parts of this. The frozen bodies of Mammoths are now and then discovered in the iron-bound soil of the Siberian tundras, and these prove the existence of a thick coat of long black over-hair, together with reddish wool, a character no doubt to be regarded as a climatal adaptation. One of the prehistoric drawings made by the men of the Stone Age (see p. 233) gives a rough outline of one of these animals, and indicates the shaggy coat. It was found in a French cavern, and executed upon a piece of mammoth tusk. The Siberian variety has long been known as a source of fossil ivory.

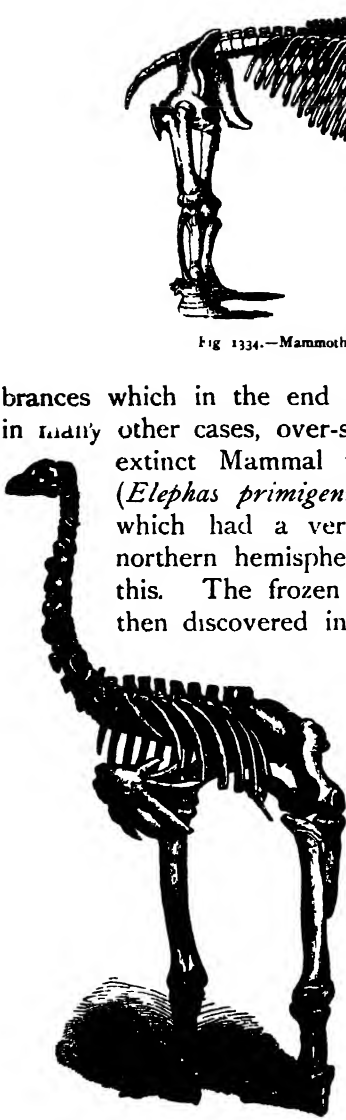


Fig. 1335.—Skeleton of Moa (*Pachyornis elephantopus*), much reduced

Kainozoic Birds (*Aves*).—Some of the extinct *Running Birds* (*Ratitæ*) are perhaps the most interesting. In New Zealand, for example, the Moas existed during the period of human occupation, and were finally exter-

minated by the Maoris. The largest form (*Dinornis maximus*) attained a height of over 11 feet. Another sort of Moa (*Pachyornis elephantopus*, fig. 1335), though not so large as this, was much more massive in build. Egg-shells and feathers of these birds have been found, as well as skeletons. The bones and egg-shells of other large running birds (*Æpyornis*) have been abundantly discovered in Madagascar, and it is not unlikely that they too owed their extinction to human agency. Some species were little inferior in size to the largest Moas. It is not improbable that the creation of the fabulous bird known as a "roc", which figures in the Arabian Nights and other Eastern stories, was originally based upon ancient traditions regarding some of the extinct running birds.

At the present time such birds are limited to the soutnern hemisphere, but we know that during early Kainozoic times they also existed in the northern half of both Old and New Worlds.

PHILOSOPHIC ZOOLOGY

CHAPTER LXXVIII

PHILOSOPHIC ZOOLOGY—THE THEORY OF EVOLUTION —EVOLUTION AS A FACT

Having now considered at some length the relations of animals to their surroundings (or environment), in which, of course, other organisms are included, and having also reviewed the life-cycles or life-histories of certain typical forms, this work may be fitly concluded by a brief survey of the Theory of Evolution, which at the present day not only dominates the realm of Natural History, but has also had a far-reaching influence upon almost every branch of learning.

The kinds or *species* of animal at present existing are almost innumerable, and we know from the geological record that a host of others once lived which are now extinct, some having become so within the historic period, while others died out millions of years ago. Until the second half of last century it was commonly believed that all these species came into existence by "special creation", and to ask "why?" any kind of animal had a particular structure, developed after a special fashion, exemplified certain habits, or lived in a definite area, was considered undesirable or even impious. The only answer to such questions given by the doctrine of special creation was that these things were so because they had been designed to be so, according to a plan into which the human mind was forbidden to pry. Now and then, however, from the time of Aristotle onwards, this paralyzing dogma failed to satisfy the minds of certain naturalists who were ahead of their times. Among these perhaps the most notable was the eminent French zoologist Lamarck, who in 1801 expressed the view that all existing species have descended from, *i.e.* been evolved from, pre-existing

species. He further propounded a Theory of Evolution, which attempted to explain *how* species have originated from those which preceded them. But comparatively little attention was paid to the evolutionary views of Lamarck and some other naturalists till the year 1858. In that year a new Theory of Evolution (now commonly known as Darwinism) was simultaneously propounded by Charles Darwin and Alfred Russel Wallace, who, working independently on facts collected in entirely different parts of the world, had reached practically the same conclusions regarding the manner in which organisms of different kind have come into existence. The publication of Darwin's epoch-making book, *The Origin of Species*, followed in 1859, and since that date the doctrine of evolution has made steady headway, at first against strong and even embittered opposition, until now the doctrine of special creation is almost entirely held by those who have had no scientific training worthy the name, together with some few others who cling tenaciously to the old and once popular view.

This chapter is concerned with the *fact* of Evolution, and not with the various theories associated with the names of Darwin and many others which attempt an explanation of that fact. The distinction between the fact and its explanation is of importance in a popular work like this. Botanists and zoologists, after the manner of their kind, are constantly engaged in polemics about all sorts of evolutionary problems, their controversies being often not a little acrimonious, and sometimes even taking a personal turn. These things, however, are not unknown among the votaries of other studies. But in such cases it is not the fact of evolution that is in question, but this or that difficult question as to the way in which it has come about. All are agreed that evolution and not special creation has been and is the primary law of organic nature, probably, indeed, of nature in general.

Since the whole of this book has been written from the evolutionary stand-point, much has already been adduced in support of the fact of evolution, and it will therefore suffice to summarize some of the chief arguments in its favour, following the order adopted by Romanes (in *Darwin and After Darwin*).

THE ARGUMENT FROM CLASSIFICATION.—If the various kinds or species of animal were absolutely separate creations we should expect to find them clearly distinguishable from one another,

but this is by no means universally the case. Indeed, it is by no means easy to exactly state what a species is. Some such definition may be given, for example, as the one by Swainson:—"A species, in the usual acceptation of the term, is an animal which, in a state of nature, is distinguished by certain peculiarities of form, size, colour, or other circumstances, from another animal. It propagates, 'after its kind', individuals perfectly resembling the parent; its peculiarities, therefore, are permanent." But unfortunately there are such things as *varieties* or *races*, which are subdivisions of species, and might be taken for such if seen in a museum. In the case of the Field Snail (*Helix hortensis*), for example, there are many such races, distinguished by variously coloured and banded shells. But in cases like this we usually find that the different varieties, when crossed, produce offspring (mongrels) which are perfectly fertile as regards one another and the parent varieties. On the other hand, the offspring (hybrids) produced by crossing two undoubted species are usually, but not always, infertile. A notable instance is seen in mules, which are obtained by crossing horses (*Equus caballus*) with asses (*E. asinus*). We further find that two or more apparently distinct species may be connected by a series of intermediate varieties. This is beautifully seen in some of the extinct Lamp-Shells and Snails, while the early turns of the spiral in some Ammonites (see p. 465) may resemble one adult species, though the later turns may correspond to another adult species. Facts of the kind cited, while only susceptible of interpretation in a mystical manner by the doctrine of special creation, harmonize very well with the evolution theory, according to which organisms are constantly being adapted to changing surroundings, and new specializations are continually coming into existence. On this hypothesis we may regard varieties as species "in the making".

Species are aggregated into larger groups known as genera, these into families, and so on, to orders, classes, and phyla or sub-kingdoms, respectively marked out by agreements and differences of increasingly broader and more general kind. If these various groups of, *e.g.*, Backboned Animals, are diagrammatically arranged so as to best express their mutual arrangements, a tree-like arrangement results (see vol. i, p. 111), the phylum corresponding to a main branch. This was perceived in pre-evolutionary days, and the only rational explanation so far given

of it is that such a tree is really a genealogical one. The conclusion is fully confirmed by the geological record.

We also find a number of existing animals which, though on the whole susceptible of classification in one group, also show points of marked agreement with members of one or more other groups. A notable instance is afforded by Peripatus (see vol. i, p. 398), which, though an undoubted Arthropod, is singularly like a segmented Worm or Annelid in some respects. If the classification tree is a genealogical one, the existence of such animals is readily intelligible. Such cases are otherwise inexplicable, unless some unintelligible and dogmatic statement offered by the believer in special creation can be so regarded.

THE ARGUMENT FROM FORM AND STRUCTURE (MORPHOLOGY).—A very large number of examples might be brought forward to show that many organs can only be rationally interpreted on an evolutionary basis. A particularly good instance is afforded by the lungs of air-breathing vertebrates, which appear to be modifications of the swim-bladders possessed by fishes (see vol. ii, p. 421). And it may be added that there are many other structural characters of these air-breathing forms which point to an aquatic ancestry. That this should be so, is only intelligible from the stand-point of evolution.

If we take a particular group of animals, say Mammals, we shall find that they are constructed on a particular plan, modified in a great variety of ways to suit the exigencies of various modes of life. This is very well illustrated by the structure of the limbs, in reference to different kinds of locomotion, *e.g.* swift progression by running on a firm surface, swimming, climbing, and burrowing, as set out in detail in the section on Locomotion (vol. iii). We have here, it would appear, a gradual Adaptation by a process of evolution to conditions of different kind.

The strongest argument from structure in favour of the doctrine of evolution is that derived from those parts of animals which are known as *vestiges* (rudimentary organs). The human body, for example, is in itself quite a museum of such structures. Indeed, one may say that it is an archæological museum, for vestiges can only be reasonably explained as the remains of organs which were of greater importance in ancestral forms. The lower end of the backbone (coccyx), for instance, looks uncommonly like the remains of what was once a tail, and the

same explanation can be given of the tailless condition of the man-like or anthropoid apes (Gorilla, &c.). The troublesome little outgrowth from the intestine familiarly known as the "appendix", which when diseased leads to appendicitis, corresponds to what is a large and useful structure in some other Mammals; and a little red fold (semilunar fold) in the inner corner of the eye appears to be the remnant of a third eyelid. And so on, almost indefinitely. Among Mammals other than

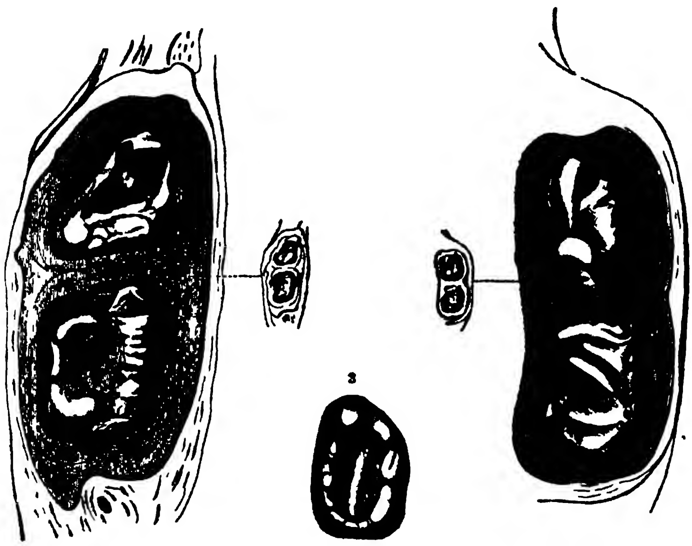


Fig 1336.—(1) and (2), Upper and lower grinding-teeth of a young Duck-Bill (*Ornithorhynchus*), natural size and enlarged; (3) grinding tooth (enlarged) of an extinct Mesozoic mammal (*Microlestes*)

ourselves we find a great variety of vestiges. Whalebone Whales, to take a well-known case, possess neither teeth nor externally visible hind-limbs. But traces of teeth are found in the jaws of very young individuals, although they are never cut. And vestigial hind-limbs are found even in adults, imbedded in the muscles of the hinder part of the body, exactly where hind-limbs should be were they fully developed. Unless we simply accept these things as inexplicable facts, we must fall back on the doctrine of evolution, and consider such structures as dwindled heritages, reminiscent of earlier conditions.

Passing from the higher Mammals to their lowest existing

relatives, we find in the Australian Duck-Bill (*Ornithorhynchus*) that the adult animal possesses four horny plates in place of teeth. But these are preceded by small molars (fig. 1336) which last for a short time only. The conclusion may be drawn that the Duck-Bill is descended from ancestors which possessed teeth when adult. And, in connection with this, it is interesting and significant that the transitory teeth of this creature are singularly like those possessed by an extremely ancient Mesozoic mammal, which has been extinct for an enormous length of time.

Argument from Development.—As already explained in the section on Development and Life-History (vol. iii), an animal of complex structure results from a process of gradual up-building, in which the ovum or egg-cell is the first and simplest stage. Speaking very broadly, the course of this development is taken to be a recapitulation of the history of the group to which the particular animal belongs. The life-history of a particular form may, for example, include stages adapted to different modes of life, and in some cases these apparently correspond to ancestral stages similarly adapted. We see this in the Frog, which is hatched out as an aquatic tadpole, breathing by gills and fitted in various other ways for life in water. From this the conclusion is drawn that the remote ancestors of Frogs were aquatic creatures, related to the stock from which recent fishes have descended. The argument may be extended to Reptiles, Birds, and Mammals, for though these do not begin life as aquatic tadpoles, all of them possess gill-slits during certain stages in their development. But these slits have nothing to do with breathing, apparently serving no useful purpose, and ultimately close up. One result of their presence in the embryo is that some of the blood-vessels develop in a somewhat roundabout manner (see vol. i, p. 244). These vessels begin in conformity to what may be called the "fish-plan", abandoning this later on for the arrangement characterizing the air-breathing adult. Such a peculiar method of development is quite unintelligible unless it is explained by reference to ancestry.

The Feather-Star (*Comatula*) furnishes a striking example of recapitulation in its life-history. It is for some time fixed to some firm object by means of a stalk, which is later on abandoned. This may very reasonably be taken to mean that

Feather-Stars have descended from fixed forms resembling the related Sea-Lilies, some of which still live in the deep sea.

THE ARGUMENT FROM THE GEOLOGICAL RECORD.—Although our knowledge of the successive faunas which have existed in the course of the earth's history is lamentably incomplete, all the facts with which we are acquainted harmonize with the doctrine of evolution (see p. 456). There has been a general progress from low to high, and many animal pedigrees have been worked out in considerable detail. Taking Hoofed Mammals and Flesh-Eaters, for instance, the geological record shows that the existing subdivisions of these orders can be traced back, respectively, to common ancestors (see p. 472). The most ancient birds known possess characters which are strong evidence of reptilian descent, and Reptiles, in their turn, are in all probability an offshoot from an amphibian stock. Similar evolutionary conclusions can be drawn in all cases where sufficiently abundant evidence is available.

THE ARGUMENT FROM GEOGRAPHICAL DISTRIBUTION.—The way in which animals are at the present time distributed over the face of the globe is susceptible of no satisfactory explanation unless we have recourse to the theory of evolution. Admitting this, and at the same time making full use of the evidence afforded by the geological record, many things which would otherwise be entirely unintelligible find an easy solution, as has already been sufficiently indicated (see p. 409). We are able in this way to understand why Tapirs are at the present time only to be found in south-east Asia and tropical America, Pouched Mammals in the Australian region and America, and similarly for many other apparent anomalies.

CHAPTER LXXIX

THE THEORY OF EVOLUTION—THE ORIGIN OF SPECIES

If we admit that the existing kinds or species of animals have arisen by a process of evolution from pre-existing species, the pertinent question "How?" demands an answer. Our ignorance is here so profound that we have so far only been able to frame working hypotheses to account for the facts. And every theory from time to time propounded leads to endless controversy, though, on the whole, we are constantly getting nearer to the heart of things. Everything depends upon the properties and possibilities of the living substance (protoplasm) which is the essential part of every organism, but it is precisely here that the gaps in our knowledge are most painfully obvious. The history of every science presents us with regularly alternating phases of fact-collection, and generalization upon facts. At the present time we badly need more facts, upon which to base further speculations as to the methods of evolution. And this is more particularly true regarding experiments on heredity and related matters, upon which satisfactory answers to evolutionary questions must necessarily depend.

We are here only concerned with a brief statement of the leading theories and principles which have so far been brought forward, commencing with the doctrine of Natural Selection, simultaneously advanced by Darwin and Wallace, and which has had a quite unprecedented influence upon the methods of human thought.

NATURAL SELECTION (DARWINISM)

This theory of evolution, which is essentially of utilitarian character, marshals together a large number of indisputable facts, suggests their mutual relations, and builds up, step by step, a very convincing hypothesis as to how and why new species have

come into existence during the countless ages for which life has existed on the earth.

It is, to begin with, sufficiently obvious that the available living space on the earth is, after all, restricted, and there must therefore be a limit to the number of plants and animals that can exist at the same time. We know, however, that all organisms tend to increase in a more or less rapid manner, yet, in a given locality, the numbers of individuals belonging to a particular species remain fairly steady. There must, therefore, be various checks preventing indefinite increase—a constant fight for life, a Struggle for Existence. Every plant and every animal is engaged in a keen competition with other forms of life, and has also to battle with the constantly-changing physical conditions which collectively constitute climate. Individuals that for any reason surpass others in this constant warfare with their surroundings are, so to speak, *selected* by Nature to carry on their race, while their less fortunate fellows go to the wall. We have, in short, the active principle of Natural Selection or Survival of the Fittest.

We have further to consider how and why it is that given individuals are thus favoured in the universal struggle for existence. The classes of facts which give us some insight into this matter may be conveniently arranged in the following tabular statement, followed by a brief discussion of the principles involved.

PROVED FACTS	NECESSARY CONSEQUENCES
Limited Surface of Globe and Rapid Increase in Numbers	Struggle for Existence
Struggle for Existence and Variation	Natural Selection or Survival of the Fittest
Natural Selection and Heredity ...	Origin of New Species

Rapid Increase in Numbers.—Darwin takes the elephant as an example of an animal of which the numbers increase with minimum rapidity, a family of six within the space of 60 years being the average, while individuals live for about a century. Supposing all the offspring to survive for the full tenure of existence, this gives a total of about 19,000,000 elephants descended from a single pair after the lapse of from 740 to 750 years.

As an example of a species which increases with great rapidity

we may take the Field Vole (*Arvicola arvalis*), which produces several broods during the same summer, some of these propagating in their turn before winter. Crampe has calculated that, if there were no checks to increase, a single pair of these animals, supposing their first brood to be born on April 15 of a given year, would be represented by the very respectable total of 198 on the following 8th of October. Continental agriculturists sometimes have a very unpleasant object-lesson as to these possibilities, for in certain "vole years" the ordinary checks to increase are inefficient, the result being that enormous numbers of field-voles make their appearance, and do an immense amount of damage to crops.

It not infrequently happens that when particular species of animals are introduced into a new country, where the checks that keep down their numbers in their native countries cease to operate, they increase in a phenomenal way. The result of introducing rabbits into Australia affords one of the best examples of this.

VARIATION AND HEREDITY.—It is a well-known fact that no two individuals of the same species are precisely alike. There is, in other words, a tendency to vary. The fact of Variation enables us to understand why certain individuals, rather than others, have a better chance of surviving in the struggle for existence. For in any given environment variations in some directions must more or less favour the animals which possess them. They are, in fact, *useful* variations, tending to greater *fitness* as regards some particular set of surroundings. In many herbivorous animals, for example, in regions where carnivorous enemies abound, it is clear that an individual varying in such a way that its locomotor powers are somewhat better than those of its fellows, will have a better chance of escaping from enemies, and also of securing an abundant supply of food. Other things being equal, it will also be more likely to perpetuate its species than more slowly moving individuals of the same species.

Next comes the question of Heredity. No one disputes the possibility of certain characters being transmitted from one generation to another. The doctrine of Natural Selection involves the view that favourable variations are thus perpetuated, and as, in each successive generation, individuals which continue to vary in favourable directions will have the best chance of surviving,

we can suppose such variations to gradually accumulate until their amount is so large as to constitute a new species.

Darwin's conclusions as to the joint result of variation and heredity were largely based on observations made upon domes-

Fig. 1337.—Blue Rock and some of the domesticated varieties of Pigeon (1), Blue Rock (*Columba livia*) (2), Tumbler, (3), Owl (4), Jacobin (5), Fantail (6), Pouter

ticated animals. We know, for example, that all the numerous breeds of pigeons (fig. 1337), such as Pouters, Fantails, Carriers, Tumblers, &c. &c., are descended from one original species, *i.e.* the Blue Rock (*Columba livia*), as the result of artificial selection by human agency. That is to say, individuals varying in some particular direction have been selected by man with a

view to producing offspring presenting the special character or characters in an increased degree.

OBJECTIONS TO THE THEORY OF NATURAL SELECTION.—At various times a number of objections have been made to the theory, some being of a very trifling and quibbling sort, others of more serious nature. It is no part of the plan of this book to enter into all the difficulties that require or have required to be met, and it may suffice to mention one of the most formidable objections, derived from the supposed "swamping effects of intercrossing". That is to say, supposing a favourable variation to have arisen, it seems at first sight that it is just as likely to gradually disappear again by intercrossing as to be emphasized by heredity, indeed more likely. Fleeming Jenkin, the first propounder of this difficulty, illustrated it by the possible case of a white man becoming king of a black island population, his whiteness typifying a favourable variation. His immediate descendants would not be white, but yellow, and in the course of several generations the royal house would probably be just as black as their subjects.

It may be added that if a number of domesticated races of, say, pigeons, are allowed to cross freely together, their peculiar characteristics gradually disappear, and the features possessed by the original wild stock are reacquired. This is generally explained as a case of reversion or atavism, or in more popular language, a "throw back" to the ancestral type.

The objection has been often met by supposing that the particular variation occurred not in one, but in a number of individuals, thus giving a better start for the formation of a new species, but such an idea requires proof. Even if we admit the probability of the occurrence, the factor of Isolation must be emphasized, as has been done by Romanes and others. Isolation of individuals presenting a certain kind of variation would certainly prevent the swamping effect of intercrossing from operating, and pigeon-fanciers, for example, could never succeed in producing new breeds if they did not sort out and keep their birds separate, according to their special requirements. Such isolation actually occurs in nature when a small number of individuals belonging to a particular species reach, say, an oceanic island, where adaptations to a new set of surroundings become necessary, and where they are separated from the original home

of their kind. And it is particularly significant to note, in this connection, that such islands are peculiarly rich in distinct species. Isolation is also exemplified by the area between tide-marks, as in some of the periwinkles. Some of these creatures are gradually becoming adapted to breathing damp air, those which are best off in this respect living near high-water mark. It is pretty clear that individuals varying so as to breathe damp air better than their fellows would naturally take to living further from the sea, and would be thus to some extent isolated.

Isolation may also be of a physiological nature, as emphasized by Romanes in his theory of *physiological selection.* We know that, as a rule, the crosses between allied species, *i.e.* hybrids, are infertile, and it is largely owing to this fact that animal species remain distinct. It seems, therefore, a plausible assumption that the rise of new species has partly been rendered possible by an increasing tendency for the crosses between them and their parent stocks to be infertile. In other words, there has been a physiological variation in the direction indicated, alongside of other variations in shape, proportion, colour, &c. &c.

SUPPLEMENTARY FACTORS OF EVOLUTION

Admitting the importance of Natural Selection, it by no means follows that it has been the only evolutionary factor determining the origin of new species.

COURTSHIP SELECTION.—Darwin believed that some of the characters of male animals have been brought about by selection exercised on the part of their mates. The possibilities in this direction have already been discussed at some length (see p. 143) in dealing with the Law of Battle and the Law of Beauty. It is, after all, a special kind of Natural Selection, which may have determined the evolution of certain weapons and of æsthetic characters.

LAMARCKISM.—Under this head may be included the pre-Darwinian views of the French naturalists Lamarck and Buffon, to which Darwin himself was inclined to attach some importance. These views turn upon the inheritance of "acquired characters", regarding which there has been an interminable amount of discussion. It must be premised that the body of an animal higher in the scale than an Animalcule is related to (1)

the existence of the individual, and (2) the existence of the species. The greater part of the body, having more particularly to do with (1), is conveniently termed the "soma" (Gk. *soma*, body), and this is the bearer of germ-cells, some of which are destined to grow into fresh individuals, and are therefore concerned with (2). An "acquired" character is one which comes into existence in the soma, as an accommodation to its mode of life, *i.e.* as an individual adjustment to surroundings. Here have to be considered the results of "use and disuse" of organs possessed by the individual. Let us take, for example, some of the sea-snails which live between tide-marks, and are accommodating themselves to breathing damp air as against air dissolved in water. The gill or gills which are specially concerned with the latter kind of breathing have less work to do than in purely aquatic forms, and there is no reason to doubt that they may therefore (as the result of partial "disuse") be slightly diminished in size in the lifetime of an individual which is migrating towards high-tide mark. On the other hand, the roof of the gill-chamber (see vol. ii, p. 460) has to do with breathing damp air, and in the lifetime of the individual supposed, may well (by "use") acquire increased specialization in connection with that duty.

According to the Lamarckian view, these two acquired characters of the soma, *i.e.* dwindling gill and specializing roof to gill-chamber, would be transmitted to the offspring. Were this so, use and disuse might ultimately lead to the evolution of a race of land-snails well adapted for air-breathing, but with gills shrunk to mere vestiges or absent altogether.

Lamarckism also involves the view that the surroundings of an animal, by their *direct* action, bring about acquired characters, positive or negative, as the case may be. We have, in other words, a direct action of the environment. Considering once more the case of a sea-snail living between tide-marks, it may be regarded as alternately subject to two influences so far as breathing is concerned, *i.e.* the action of the water which covers it for part of its existence, and the action of the damp air which surrounds it during the other part. The former favours gill-retention, the latter gill-reduction, and conversely as regards the arrangement for breathing ordinary air. Near low-tide mark the influence of water is obviously predominant, and near high-tide mark the action of air is more felt.

Some further remarks will be made about acquired characters in the sequel.

NEO-LAMARCKISM.—It is difficult to sum up in a few words the beliefs of the Neo-Lamarckian school. They essentially involve the view that there are general Laws of Growth, leading to progress in definite directions, by means of successive variations of the same kind. The action of Natural Selection is largely discounted.

This chapter may perhaps best be concluded by the addition of a few remarks on Variation and Heredity.

VARIATION

Beyond the fact that living matter *does* vary, we know very little. No clear answer can as yet be given to the questions *why* this should be so, and *how* variations of a given kind are brought about. There can be no doubt, however, that the individuals of any particular species differ from one another in a great variety of ways, and often to a very considerable amount. There is, in fact, an illimitable field for the action of selected principles. Many variations, too, are sudden or *discontinuous*, and probably new species have been often evolved at a much more rapid rate than supposed by Darwin, who believed in the selection and accumulation of *small* variations. Since his time our knowledge of variational possibilities has been largely increased.

There can be no doubt that a large majority of the characters of animals are *adaptations* to the environment, *i.e.* fit them to live in relation to certain surroundings. The origin of such adaptations must naturally be sought in variations. Here it is necessary to clearly distinguish between variations of the soma and variations of the germ, *i.e.* somatic and germinal variation. As we have seen, the Lamarckians believe that the former (acquired characters) can be transmitted. According to the school of Weismann, on the other hand, it is only the germinal variations which are capable of transmission. As, of course, the development of a germ-cell into an individual means the production of a new soma as well as more germ-cells, this new soma will have been influenced by variations which have taken place in the germ from which it has been developed. That is to say, the character of a soma mainly depends upon the char-

acters of the germ from which it has been developed, but the soma has no direct influence upon the germs of which it is the bearer.

Organic Selection.—Lloyd Morgan, Baldwin, and Osborn have elaborated a view (of which Weismann himself suggested the possibility) as to the possibility of co-operation between germinal and somatic variations in the interests of the species. Even if we admit that the latter (acquired characters) are non-transmissible, it by no means follows that they have no evolutionary import. However unimportant the soma may be as to the provision of variations that can be inherited and so help in the making of new species, it is at least the bearer of germ-cells, to which its survival and well-being are of the first importance. If, therefore, it is able to accommodate itself to its surroundings so as to survive and leave offspring, it will give variations which have arisen in its germ-cells a chance of being preserved. Accommodation, *i.e.* the rise of acquired characters, is consequently intimately bound up with the adaptation of the species.

It must not be regarded as definitely settled that acquired characters are never transmitted, although many supposed instances have been explained away. A vast amount of observation and experiment is still necessary, and dogmatism is at present quite out of place.

The question still remains as to whether variations are independent of the action of the environment, directly due to its action, or to some extent dependent upon it. There are probably perhaps several possibilities. The germ-cells, for instance, are in many cases so sheltered from the action of surroundings that some of their variations may well be inherent. It is also well-nigh certain that there is such a thing as environmental variation. But here there are two possibilities. The action of the surroundings may directly set up variations, or it may simply act in such a way as to favour variational possibilities, *i.e.* it may direct and further, but not absolutely initiate. Nor is its action necessarily limited to either alternative.

HEREDITY

In cases of egg-development it is necessarily the germ-cells that are the means of transmitting characters from one generation to the next. Innumerable investigations upon such cells

also render it practically certain that the part concerned with heredity is the *nucleus*, *i.e.* the specialized particle of protoplasm which every germ-cell contains. Weismann limits the field still further, and considers that the nucleus is in part composed of "germ plasma", a protoplasmic material specially concerned with the transmission of characters. In typical egg-propagation (see vol. iii, p. 335) germ-cells from the two parents fuse together, and the essential point about the process seems to be the union of the two nuclei. This has undoubtedly an important bearing on the question of heredity, but precisely what bearing is still a matter of doubt. It is perhaps the most remarkable fact in the whole realm of knowledge that the fusion of two microscopic particles of protoplasm should carry with it so vast a range of possibilities as regards inheritance.

There are some clear cases which prove that the germ-cells are influenced by some of the factors in the surroundings. Yung, for example, by bringing up tadpoles on specially nutritious food, was able to produce with certainty an abnormal proportion of females (90 per cent or even more), and we have elsewhere seen (see p. 256) that a fertilized bee's egg may give rise to either a worker or queen, according to the nature of the food received by the larva. Even more remarkable is the case of certain lowly crustaceans upon which Schmankewitsch experimented. In the course of several generations he was able to convert a species (*Artemia Milhausenii*) living in saltish water into another species (*A. salina*), by gradually increasing the amount of salt. He also found it possible to conduct the experiment in the reverse order, and in this instance was able to go a step further, obtaining a third species of a distinct genus (*Branchipus stagnalis*), characteristic of perfectly fresh water. In the light of such facts it seems difficult to believe that there is no possibility of acquired somatic characters being transmissible, for we can scarcely maintain that in all the cases cited the germ-cells were directly influenced by modification in the surroundings.

Galton has formulated a law (since modified by Karl Pearson) expressing numerically the influence of parents and remoter ancestors upon the characters of offspring, and the application of mathematical methods to biological statistics is likely to yield important results in the immediate future, as regards heredity, variation, and many other problems. On the botanical side very

remarkable results bearing on the theory of heredity have been obtained by applying the principles of Mendel, but these cannot be discussed here, especially as there are difficulties in the way of conducting similar experiments on animals.

Readers who wish to acquire further knowledge in matters relating to biological theory would do well to consult the works of Darwin, Wallace (especially *Darwinism*), Romanes (*Darwin and After Darwin*), Weismann, Lloyd Morgan, Verworn (*General Physiology*), E. B. Wilson (*The Cell in Development and Inheritance*), T. Hunt Morgan (*Evolution and Adaptation*), and Mendel (*Principles of Heredity*). A good preliminary acquaintance with the subject may be obtained by reading Arthur Thomson's *Science of Life.*

GLOSSARY

Abomasum, in the stomach of Ruminants, the fourth compartment (chemical stomach).

Abysmal zone (Gk. *abyssŏs*, very deep), the deepest part of the sea.

Accommodation, adjustment of the individual to its surroundings.

Acetabulum (L. for vinegar cup), the socket in the hip into which the thigh-bone fits.

Acquired character, a character acquired by an individual in relation to its surroundings.

Adaptation, the adjustment of species to their surroundings.

Adductor muscles (L. *adduco*, I lead to), muscles which by their contraction close the shells of Bivalve Molluscs, Lamp-Shells, and Mussel-Shrimps.

Adipose fin, the small, fatty second dorsal fin of members of the Salmon Family.

Æsthetic or **Æsthetics** (Gk. *aisthētikŏs*, sensitive), the philosophy of the beautiful.

Afferent branchial vessels (L. *affĕrō*, I carry to; Gk. *branchia*, gills), blood-vessels which carry impure blood to gills to be purified.

Afferent nerve-fibre (L. *affĕrō*, I carry to), a nerve-fibre in which the impulse travels towards the central organs.

Air-bladder. See *Swim-bladder.*

Ala spuria. See *Bastard-wing.*

Albinism (L. *albus*, white or pale), exceptional whiteness or paleness in hue of some members of a species.

Albino, an individual exhibiting albinism.

Albumen, or **Albumin**, the complex albuminoid (which see) of which the white of an egg is made up.

Albuminoids, complex compounds, chiefly made up of carbon, hydrogen, oxygen, sulphur, and (in some cases) phosphorus.

Alima, pl. **-æ**, in Mantis-Shrimps, an attenuated kind of larva.

Ambergris, concretions formed in the intestine of the sperm-whale. Used in perfumery.

Ambulacral, relating to an ambulacrum; Ambulacral area, a band or zone bearing tube-feet; Ambulacral ossicle, one of the calcareous plates roofing an ambulacrum.

Ambulacrum, pl. **-a** (L. for pleasure grove), in Star-Fishes, one of the grooves in which the tube-feet are lodged.

Ammocætes, the larva of a Lamprey.

Amœboid movement, irregular flowing or creeping movements, performed by naked masses of protoplasm, *e.g.* in the Proteus Animalcule (Amœba).

Amphibious (Gk. *amphi*, both ways; *bĭŏs*, life): (1) able to breathe both ordinary air and air dissolved in water; (2) breathing dissolved air during the early part of life and ordinary air afterwards.

Ampulla (L. *ampulla*, a flask): (1) in the internal ear of Vertebrates, the swollen part of a semicircular canal; (2) in Echinoderms, a small sac connected with a tube-foot.

Anabolic, relating to anabolism.

Anabolism (Gk. *anabŏlē*, an ascent), the up-building chemical processes that take place within the body.

Analogous, displaying analogy.

Analogy (Gk. *analŏgŏs*, in agreement with), applied to parts which do the same physiological work irrespective of relative position and mode of development. See also *Homology.*

Anatomy (Gk. *anatomē*, dissection), the study of structure.

Anbury, in turnips, a disease due to the presence of a fungus-animal (*Plasmodiophora brassicæ*).

Antenna (L. for yard-arm): (1) one of the feelers of an Insect, or Myriapod; (2) one of the second feelers of a Crustacean; (3) one of the head-feelers of a Bristle-Worm.

Antennary gland, in higher Crustaceans, one of a pair of excretory organs by which nitrogenous waste is removed from the body. They open at the bases of the antennæ.

Antennule, in Crustaceans, one of the small first pair of feelers.

Anthrax, in cattle, &c., a bacterial disease, often set up by insect bites.

Anthropoid (Gk. *anthrōpŏs*, man; *eidŏs*, appearance), man-like.

Anti-toxin (Gk. *anti*, against; L. *toxicum*, poison), a complex organic substance (defensive proteid) conferring immunity against disease-germs.

Antler, in Deer, a bony outgrowth from the skull, which is shed annually.

Antler-royal, the third branch of a Red Deer's antler (counting from its base).

Aorta (Gk. *aēiro*, I carry), the chief artery of the body.

Aortic arches, the arteries which traverse the visceral arches of Vertebrates.

Apical disc, in Echinoderms (especially sea-urchins), a double circlet of plates on the upper surface of the body.

Apiculture (L. *apis*, a bee), bee culture.

Apteria (Gk. *a*, without, *pteron*, a feather), featherless patches of a Bird's skin.

Arch, of a vertebra (or joint of the backbone), the dorsal part which forms the roof and sides of the hole traversed by the spinal cord.

Archenteron (Gk. *archē*, a beginning, *enteron*, an intestine), the digestive cavity of the Gastrula (which see).

Area of distribution, area inhabited by a species or other animal group. It is *discontinuous* if consisting of two or more isolated portions.

Artery, a blood-vessel which carries blood from the heart.

Articular processes, projections on the arches of vertebræ, by which these are connected together.

Artificial selection, the production of breeds of domesticated animals by human agency.

Assimilation (L. *ad*, *similis*, I make like), the conversion of digested food into body substance.

Atavism (L. *atavus*, an ancestor). See *Reversion*.

Atlas, the ring-shaped first vertebra of the backbone.

Atoll, a ring-shaped coral island.

Atrial cavity [illegible] space surrounding [illegible] the pharynx in Lancelets and Ascidians.

Atriopore, the [illegible] of the Atrial cavity [illegible]

Auricle [illegible] which veins [illegible]

Auricularia, pl. -æ [illegible] in [illegible] provided [illegible] the [illegible]

Australian region, Australia and adjacent islands [illegible] East Indies, New Zealand and Polynesia.

Axis, the second neck vertebra.

Balancers (halteres), small club-shaped structures representing the reduced hind wings in Flies.

Baleen ("whalebone"), in toothless Whales, elastic plates hanging down from the roof of the mouth.

Barb, one of the flattened branches borne by the axis of a feather.

Barbel, one of the sensitive filaments with which the mouth-region is provided in some Fishes, *e.g.* Cat-Fishes.

Barbule, one of the small branches borne by the barbs of a feather.

Bastard-wing (ala spuria), a tuft of feathers borne by the thumb of a bird.

Bêche-de-mer, Trepang (which see).

Bedeguar, a tufted gall on the rose, produced by the attack of a Gall-Fly.

Beneficials, those wild animals that by their habits promote the welfare of mankind.

Benthos (Gk. *benthos*, depth), the assemblage of animals inhabiting deep water.

Bez-tine, the second branch of a Red Deer's antler (counting from its base).

Biconcave, hollow on both sides, *e.g.* the vertebra of a Fish.

Bicuspid. See *Premolar*.

Bilateral Symmetry. See *Symmetry*.

Bile, or **Gall**, the secretion of the liver.

Bile-duct, a tube through which bile passes into the intestine.

Biology (Gk. *bios*, life, *logos*, a discourse), the science of life.

Bipinnaria, pl. -æ, in Star-Fishes, the bilateral larva, which is provided with pairs of soft ciliated arms.

Bivalve, applied to the shell of a Mollusc when made up of two pieces or valves, *e.g.* in a Mussel. Lamp-shells (Brachiopoda) are also bivalve, and Mussel-Shrimps (Ostracoda) possess a bivalve shield or shell.

Blastopore (Gk. *blastos*, a germ, *poros*, a passage), the mouth of a Gastrula (which see).

Blastosphere (Gk. *blastos*, a germ, *sphaira*, a sphere), a hollow and spheroidal kind of Blastula (which see).

Blastula (Gk. dim. of *blastos*, a germ), the embryonic stage resulting from Cleavage (which see).

Blight, a disease of plants, often due to the presence of aphides.

Blubber, in marine mammals a thick layer of fat below the skin.

Body-cavity, in animals higher than Zoophytes, a space or series of spaces between the internal organs and body wall.

Botany (Gk. *botanē*, a plant), the science dealing with plants.

Bouchot, in mussel culture, a collector made of stakes with interwoven twigs.

Brachiolaria, pl. -æ, a variety of the Bipinnaria (which see).

Bronchus, pl. -i, one of the two main branches of the wind-pipe.

Brood-parasitism, used of animals (*e.g.* the Cuckoo) which evade the responsibility of bringing up their own young.

Brow-tine, the lowest branch of a Red Deer's antler, projecting over the forehead.

Byssus (Gk. *byssos*), adhesive threads by which some Bivalve Molluscs attach themselves.

Cæcum, pl. **-a** (L. *cæcus*, blind), a blindly ending tube

Calcaneum (L. for heel), the heel-bone.

Calcar (L. for spur), a small pointed projection on the inner side of a Frog's hind-foot.

Calcareous (L. *calx*, *calcis*, lime), of a limy nature.

Callosity, a hardened patch of skin.

Calyx (Gk. *kalyx*, a cup), the outer investing leaves of a flower.

Canine, one of the four "eye-teeth" in a Mammal. Situated outside the Incisors (which see), and well developed in carnivorous forms.

Cannon-bone: (1) in Horse, &c., the large metacarpal or metatarsal of the single digit; (2) in Ruminants, the compound bone formed by fusion of third and fourth metacarpals or metatarsals.

Capillaries (L. *capillus*, hair), microscopic blood-vessels with exceedingly thin walls. The name is misleading, since they are much smaller than the finest hairs.

Carapace, a firm protective shield covering the upper side and flanks in some animals.

Cardia (the Greek name), the opening between gullet and stomach.

Cardo (L. for hinge), the basal joint of an Insect's second jaw.

Carinate (L. *carina*, a keel): (1) with a keel-like projection; (2) applied to flying birds, in which the breast-bone possesses such a projection, for the attachment of the muscles of flight.

Carnassials (L. *carnosus*, relating to flesh), or **Flesh-teeth**, in Carnivores, four cutting cheek-teeth which act like scissors.

Carnivorous, flesh-eating.

Carotid (Gk. *kārā*, the head), a term applied to arteries which carry blood to the head and neck.

Carpale, pl. **-ia** (Gk. *karpŏs*, the wrist), the distal elements of the carpus.

Carpel (Gk. *karpŏs*, fruit), a modified flower-leaf that bears ovules. The Pistil (which see) consists of one or more carpels.

Carpus (Gk. *karpŏs*, the wrist), the skeleton of the wrist.

Cartilage, gristle.

Caste, in social Insects, a set of similar individuals.

Caval veins, in air-breathing Vertebrates, the great veins which return impure blood to the heart.

Caviare, the preserved hard roes (ovaries) of the sturgeon.

Cell, a nucleated mass of protoplasm, generally microscopic, and usually regarded as the unit of structure.

Centrale, a central element of the carpus or tarsus

Centrum, pl. **-a**, of a vertebra, the relatively massive ventral part, flooring the hole traversed by the spinal cord.

Cephalo-thorax (Gk. *kĕphalē*, the head; *thōrax*, the chest), in some Arthropods, the front region of the body, formed by fusion of the head with part or all of the thorax.

Cerata (Gk. *kĕrata*, horns), in Sea-slugs (Nudibranchs), club-shaped outgrowths springing from the back.

Cercaria, pl. **-æ** (Gk. *kĕrkŏs*, a tail), in Flukes, a tadpole-shaped stage in the life-history Produced by the Redia (which see), and immediately preceding the adult stage.

Cerci (Gk. *kĕrkŏs*, a tail), jointed rods projecting from the hinder end of an Insect's abdomen.

Cere (L. *cera*, wax), a bare patch of skin at the base of a Bird's beak.

Cerebellum (L. dim. of *cerebrum*, the brain), an unpaired dorsal outgrowth from the hinder part of the brain of a Vertebrate.

Cerebral hemispheres (L. *cerebrum*, the brain), the highest part of the brain in Vertebrates, usually consisting of a pair of outgrowths from near its front end.

Cervical (L. *cervix*, the neck), relating to the neck.

Chalaza (Gk. for hail), in a Bird's egg, a twisted cord-like structure traversing the albumen ("white") at either end.

Cheek-teeth, the back-teeth.

Chelicera, pl. **-æ**, (Gk. *chēlē*, a claw; *kĕras*, a horn), one of the first pair of head limbs in Spider-like animals (Arachnida).

Chlorophyll (Gk. *chlōrŏs*, grass green; *phyllŏn*, a leaf), or **Leaf-green**, the characteristic pigment of green plants. It also occurs in a few lower animals.

Chordotonal organ (Gk. *chŏrdē*, a string; *tenaos*, stretched), in some Insects, a kind of sense organ related to balance, or hearing, or both.

Choroid (Gk. *chŏriŏn*, skin; *eidŏs*, appearance), the middle coat of the eyeball. It is pigmented and vascular, and externally forms the iris (which see).

Chromatophore (Gk. *chrōma*, colouring matter; *phĕrō*, I bear), a small or minute body containing pigment, and situated in the skin. Colour-changes are due to the alteration in size of such bodies.

Chrysalis, pl. **-ides** (the Greek name), the pupa of a Moth or Butterfly.

Ciliary action, the movement of cilia.

Cilium, pl. **cilia** (L. *cilium*, eyelash), a microscopic thread of protoplasm, possessing the power of alternately bending and straightening. Numerous cilia are usually associated together. The derivation is misleading.

Circulatory organs, the structures concerned with distributing blood and lymph throughout the body.

Cirrus, pl. **-i** (L. *cirrus*, a tentacle): (1) one of the slender-jointed appendages of a Barnacle; (2) one of the sensory filaments borne by the segments of Bristle-Worms; (3) in Sea-Lilies, one of the jointed threads of which numerous circlets are borne by the stalk.

Claire, in French oyster culture, a muddy salt pond in which oysters are 'greened' by feeding on minute algæ.

Clavicle, the collar-bone.

Cleavage, the early divisions of the fertilized egg-cell, resulting in a Blastula (which see).

Clitellum (L. *clitellæ*, a pack-saddle), in Earth-Worms and Leeches, a glandular region of the skin, which secretes the material for the cocoon.

Cloaca (L. *cloaca*, a sewer), a chamber into which, *e.g.* in a Frog, intestine, excretory organs, and reproductive organs open.

Coccyx (Gk. for cuckoo), the reduced tail-region of the backbone in Man and the man-like Apes.

Cochineal, a red pigment extracted from the dried bodies of Cochineal Insects.

Cochlea (L. *cochlea*, a snail-shell), in Mammals, a spirally-coiled part of the membranous labyrinth.

Cocoon, a variously shaped case in which the eggs or other inactive stages in the life-history of various animals are enclosed.

Cœlom (Gk. *koilŏs*, hollow), a Body-cavity (which see) containing lymph-like fluid and communicating with the exterior by excretory tubes.

Cœnosarc (Gk. *koinŏs*, common; *sarx*, *sarcos*, flesh), in colonial Zoophytes, the common body by which the individuals are united.

Collar-cell, in Sponges, a cell bearing a single flagellum with a collar-like projection at its base.

Collector, in oyster- and mussel-culture, an arrangement of twigs, boards, or tiles, to which the larvæ or fry attach themselves.

Colonial, relating to a Colony (which see).

Colony, an assemblage of lower animals, in which the bodies of all the individuals are continuous. The condition is a result of vegetative propagation.

Columella (L. *columella*, a little pillar), a small rod which stretches across the drum of the ear in Birds, some Reptiles, and some Amphibians.

Columnar epithelium, epithelium composed of cells elongated at right angles to the surface.

Commensalism (L. *con-*, together; *mensa*, a dining-table), the association of two organisms as messmates, or commensals, to the benefit of one or both.

Compound eye, an eye made up of more or less numerous optically distinct elements each with an external facet. Possessed by many Arthropods.

Concha (L. *concha*, a shell) the ear-flap of a Mammal.

Condyle (Gk. *condylos*, a tubercle), a rounded projection on a bone or cartilage, where it helps to form a movable joint. Mandibular condyles, at back of lower jaw, where it unites with skull. Occipital condyle (or condyles), on back of skull, where it joins the backbone.

Conjugation (L. *conjugato*, *conjugatum*, to bind together), in some Animalcules, the temporary or permanent fusion of two individuals, accompanied by union of nuclear material, and having an invigorating effect, shown by active vegetative propagation.

Continental island, an island that was at one time part of an existing continent.

Contractile, endowed with contractility.

Contractility, the power possessed by protoplasm of changing its shape with no or slight change in volume.

Coracoid bone (Gk. *kŏrax*, a raven), a ventral element in the shoulder-skeleton of lower Vertebrates. Coracoid process, a projection (compared in Man to a raven's beak) on the shoulder-blade of Mammals, equivalent to the coracoid bone.

Cornea (L. *corneus*, horny), a transparent area of the sclerotic coat through which light enters the eye.

Corolla (L. for little crown), the inner investing leaves of a flower. Usually brightly coloured.

Corpus callosum (L. for hard body), a band of nerve-fibres which in most Mammals connects the cerebral hemispheres.

Corpuscles (L. dim. of *corpus*, a body), microscopic bodies floating in blood or lymph. White or Colourless Corpuscles, nucleated cells, able to change their shape, found in both blood and lymph. Red Corpuscles, round or oval discs present in the blood of many animals

Cortex (L. *cortex*, bark), the external layer of the cerebral hemispheres and cerebellum.

Costal (L. *costa*, a rib), relating to the ribs.

Courtship coloration, beautiful colours displayed (usually by the male) as a courtship accessory.

Courtship selection, preferential mating, as determined by combat, or by the possession of æsthetic characters.

Cranial flexure, a bend in the brain.

Cranial nerves, the nerves which arise from the brain.

Cranium (Gk. *krāniŏn*, the skull), the brain-case.

Crop, in the gut of various animals, a dilated part of the gullet, or enlarged region following the gullet. It serves for temporary storage of food.

Cross-fertilization, fertilization of an egg-cell by a sperm (or its equivalent) derived from another organism.

Cross-pollination, transfer of pollen from the stamens of one flower to the stigma of another flower.

Coxa (L. *coxa*, a hip), the basal joint of an Insect's leg.

Cul de mulet, Sea-anemones used as an article of food in parts of southern Europe.

Cultch, in oyster-culture, empty shells, broken tiles, &c., upon which oysters are grown.

Cuticle, an elastic exoskeleton of horny consistency external to the epidermis, by which it is secreted.

Cysticercus, pl. -i (Gk. *cystis*, a bladder; *kĕrkŏs*, a tail), in most Tape-Worms, the bladder-worm stage.

Darwinism. See *Natural selection*.

Degeneration, a process of simplification whereby some forms adapt themselves to a parasitic or to a fixed mode of life.

Denitrifying, used of bacteria which liberate nitrogen from organic matter.

Dental formula, a numerical expression, showing the number and kinds of teeth present in a given species of Mammal.

Dentine (L. *dens*, *dentis*, a tooth), a hard substance of which teeth are chiefly composed.

Dermatoptic vision (Gk. *dĕrma*, *-atŏs*, a skin; *optikŏs*, pertaining to sight), seeing by means of the skin.

Dermis (Gk. *dĕrma*, a skin), the inner layer of the skin.

Diaphragm (the Greek name), the midriff.

Didactyle (Gk. *di-*, two; *daktylŏs*, a finger or toe), possessing two digits.

Digitigrade (L. *digitus*, the toe of an animal; *grado*, I walk), walking upon the digits.

Diphycercal (Gk. *diphyēs*, double; *kĕrkŏs*, a tail). See *Protocercal*.

Diploblastic (Gk. *diplous*, double; *blastŏs*, a germ), applied to animals in which the body is essentially composed of two cellular layers.

Dispersal, the spreading of a species from the area where it was first evolved.

Dorsal (L. *dorsum*, the back), applied to the upper side of an animal.

Ductless glands, a name applied to a number of small structures, of various use, which do not possess ducts or tubes for carrying off a liquid secretion. See *Lymphatic glands*, *Thymus*, *Thyroid*, *Spleen*.

Ectoderm (Gk. *ĕktŏs*, outside; *dĕrma*, a skin), the external cellular layer of the body.

Ectoparasite. See *Parasite*.

Eder-fold, one of the nesting-grounds of the eider-duck.

Efferent branchial vessels (L. *effĕrŏ*, I carry from; Gk. *branchia*, gills), blood-vessels which carry off purified blood from gills.

Efferent nerve-fibre (L. *effĕrŏ*, I carry from), a nerve-fibre in which the impulse travels outwards from the central organs.

Élevage, in French oyster-culture, the rearing of young oysters to a marketable size.

Éleveur, a French oyster-culturalist concerned with élevage.

Elytron, pl. -a, (Greek name for (1)): (1) in Insects, a fore-wing modified into a hard cover for the delicate hind-wing; (2) in some marine Bristle-Worms, a breathing-scale.

Embryology (Gk. *ĕmbryŏn*, an embryo; *lŏgŏs*, a discourse), the study of the development of animals.

Endoderm (Gk. *ĕndŏn*, within; *dĕrmă*, a skin), the internal cellular layer of the body.

Endoparasite. See *Parasite*.

Endoskeleton, internal hard parts serving for support, &c.

Entomophilous (Gk. *ĕntŏmŏs*, an insect; *phileō*, I love), of flowers, pollinated by insects.

Environment, the sum total of an animal's surroundings.

Eozoic epoch (Gk. *eos*, dawn; *zoē*, life), the most ancient geological era.

Ephippium (Gk. *ĕphippiŏn*, a saddle-cloth), in Water-"Fleas", a saddle-shaped thickening of the parent-shell, serving to enclose and protect the winter-eggs.

Ephyra, pl. -æ, a young jelly-fish of flattened form, produced by transverse fission of a fixed Zoophyte.

Epidermis (the Greek name), the protective outer layer of the skin.

Epigenesis (Gk. *ĕpi*, after; *gennaō*, I produce), the accepted view that development of animals is a process involving a gradual up-building from simple to complex. See *Preformation*.

Epiglottis (the Greek name), in Mammals, an elastic flap which prevents food from entering the wind-pipe.

Epipodium, pl. -ia (Gk. *epi*, upon; *pous*, *pŏdŏs*, a foot), in some Molluscs, a muscular flap arising high up either side of the foot.

Epipubic, connected with the front end of the Pubis (which see).

Epithelium, pl. -a, layers of cells covering external and lining internal surfaces.

Ethiopian region, south Arabia with Africa south of the Sahara.

Euglenoid movement, a wriggling mode of creeping effected by altering the shape of the body, as in Euglena, a sort of Animalcule.

Eustachian tube, a passage connecting the drum of the ear with the pharynx in air-breathing Vertebrates.

Evolution (L. *evolutio*, an unfolding), the development of species by modification of pre-existing species. See also *Special creation*.

Excretion, the getting rid of waste products.

Exhalent. See *Siphon*.

Exoskeleton, external hard parts serving for support, &c.

Extensor, applied to muscles which straighten or extend a limb, or region of the body.

Fascine, in oyster-culture, a bundle of twigs used as a spat-collector.

Femoral, relating to the thigh.

Femur (L. for thigh): (1) the thigh-bone of Vertebrates; (2) a part of the leg in Insects, &c.

Fenestra ovalis (L. for oval window), in Vertebrates, a membrane-filled vacuity in the

outer wall of the firm capsule containing the essential organs of hearing.

Fertilization, the fusion of two nuclear masses, commonly derived from different individuals.

Fetlock, in limbs of Horse, &c.: (1) the knuckle-joint of the single digit; (2) the tuft of hair attached to this joint.

Fibula (L. for bodkin), the bone of the lower leg which is on the little-toe side.

Fibulare, a proximal element of the tarsus, situated on the side next the little toe.

Filoplume, a small and imperfect feather, of downy texture.

Finger-and-Toe. See *Anbury*.

Fin-rays, in Fishes, skeletal rods which support the fins.

Fins, in various aquatic animals, flat expansions of the body used in swimming.

Fission (L. *findo*, *fissum*, to split), vegetative propagation by splitting of the parent body

Flagellum, pl. -a (L. for whip-lash), an elongated thread of protoplasm, capable of executing lashing movements. A single cell bears but one or a few. See *Cilium*.

Flexor, applied to muscles which bend or flex a limb, or region of the body.

Fluke, in Cetaceans, one of the tail-lobes.

Fly-sickness, a fatal disease of horses, &c., set up by the attacks of the tsetse-fly.

Food-vacuole, in Animalcules, a food-containing space within the body.

Food-yolk, nutritive material stored up in (or outside) the egg-cell, for use during development.

Foot: (1) in broad sense, the extremity of any limb used for locomotion; (2) more strictly, the extremity of a hind-limb in Vertebrates; (3) an unpaired muscular projection from the under side of a Mollusc, used in locomotion.

Foot-stump. See *Parapod*.

Foramen, pl. -ina (L. for hole), a hole through which (usually) a nerve or blood-vessel passes. Foramen magnum, the large opening in the back of the brain-case, where brain and spinal cord are continuous.

Foramina repugnatoria, in Millipedes, small pores on the sides of the body, by which the stink-glands open.

Fore-gut, the front part of the digestive tube, developed as an inpushing from the exterior.

Fossils (L. *fossilis*, dug out), the remains of organisms, or proofs of their existence, which have been naturally imbedded in rocks.

Frenulum (L. dim. of *frenum*, a bridle), in Moths, one or more bristles projecting from the front of the hind-wing, and attaching this to the fore-wing by interlocking with the Retinaculum (which see).

Funicle (L. *funiculus*, a cord), in Moss-Polypes, a fibrous band connecting the stomach with the body-wall.

Funnel, a muscular tube through which Cuttlefishes, &c., eject water from the gill-cavity, and are enabled to swim.

Furcula (L. for a prop), the "merry-thought" of a Bird, consisting of the two collar-bones united together.

Galea (L. for a helmet), in Insects, the outer branch of the second or third jaw.

Gall: (1) bile; (2) an abnormal external growth resulting from the attack of a parasite.

Gall-bladder, a membranous bag in which bile is temporarily stored.

Ganglion, pl. ganglia (Gk. for a small tumour), an aggregation of nerve-cells.

Ganglion-cell. See *Nerve-cell*.

Ganoid (Gk. *ganos*, brilliancy; *eidos*, appearance), applied to the regularly arranged bony plates (ganoid scales) covering the bodies of some Fishes.

Gapes, in Birds, a disease due to the presence of parasitic worms (*Syngamus trachealis*) in the air-passages.

Gastric glands, minute tubes imbedded in the lining of the stomach, and secreting gastric juice.

Gastric juice, a digestive fluid secreted or elaborated by the gastric glands. It acts on albuminoids, converting them into soluble diffusible peptones.

Gastric mill, in Crustaceans, a chewing apparatus with which the stomach is provided.

Gastrula (L. dim. from *gaster*, a stomach), a double-layered embryo possessing mouth and digestive cavity (archenteron).

Gemmation (L. *gemma*, a bud), production of new individuals by budding.

General aggressive resemblance, applied to predaceous forms which harmonize in appearance with their surroundings, and are thus rendered inconspicuous.

Genus, pl. genera (L. for a race or family), a classificatory group including one or more species.

Germinal disc, that part of the egg which, *e.g.* in a Bird, develops into the embryo.

Germinal variation, variation of germ-cells (ova and sperms).

Germ Plasma, that part of the nucleus of a germ-cell concerned (according to Weismann) with heredity.

Gill arches and clefts, in Fishes, &c., those visceral arches and clefts (which see) related to the gills.

Gill-cover, or **Operculum**, (pl. -a), in many Fishes, &c., a flap which covers the gill-slits.

Gill-rakers, in some Fishes, filaments projecting from the edges of the inner openings of the gill-pouches, and serving as a straining-apparatus.

Gizzard, in various animals, a thick-walled part of the digestive tube in which food is broken up.

Glenoid cavity (Gk. *glēnē*, a shallow socket), the socket into which the bone of the upper arm fits.

Glochidium, pl. -a, the larva of a Freshwater Mussel.

Glottis (the Greek name), the opening of the windpipe in the floor of the pharynx.

Gonophore (Gk. *gŏnŏs*, offspring; *phĕrō*, I bear), in Zoophytes, a bud in which egg-cells or sperms are produced.

Green glands. See *Antennary gland.*

Grey matter, that part of the central nervous system made up largely of nerve-cells.

Ground-Pearl, in some Scale-Insects, the encysted underground pupa.

Gular (L. *gula*, the throat), near the throat.

Gut, the digestive tube or alimentary canal.

Hæmoglobin (Gk. *haima*, blood; *globin*, a kind of albuminoid), a complex substance to which red corpuscles owe their colour, and which in some animals may be dissolved in the blood-plasma. Acts as an oxygen-carrier.

Halteres (L. for club-shaped weights used by gymnasts). See *Balancers.*

Haptic (Gk. *haptikŏs*, endowed with the sense of touch), used of sensations of contact.

Herbivorous, plant-eating.

Heredity, the transmission of characters from one generation to another.

Heterocercal (Gk. *hĕtĕros*, diverse; *kĕrkŏs*, tail), unsymmetrical. Used of the tail-fin of certain Fishes, *e.g.* Sharks.

Heterodactylous (Gk. *hĕtĕrŏs*, different; *daktylŏs*, a toe), in the feet of some climbing Birds, with the first and second toes turned back, while the third and fourth are directed forwards.

Hind-gut, the hinder part of the digestive tube, developed as an inpushing from the exterior.

Hip-girdle, the skeleton of the hip-region.

Histology (Gk. *histŏs*, a texture; *lŏgŏs*, a discourse), or **Minute anatomy**, the study of structure by means of the compound microscope.

Hock, in hind-limb of Horse, &c., the ankle.

Holarctic (Gk. *hŏlŏs*, all; *arktŏs*, the north), native to the colder parts of the Northern Hemisphere.

Homocercal (Gk. *hŏmŏs*, like; *kĕrkŏs*, a tail), applied to the lobed and externally symmetrical tail of ordinary Fishes.

Homologous, displaying homology.

Homology (Gk. *hŏmŏlŏgŏs*, agreeing), applied to parts which resemble one another as regards relative position and mode of development, irrespective of use or function. Serial homology, agreement between structures forming a series, *e.g.* spinal nerves. See also *Analogy.*

Honey-comb stomach. See *Reticulum.*

Host, an organism on which a parasite preys. See *Parasitism.*

Humeral, related to the upper arm.

Humerus (the Latin name), the upper-arm bone.

Hybernation, the habit of passing into a torpid state during the cold or dry season.

Hybrid (L. *hybrida*, a cross-bred animal), a cross between two distinct species. Hybrids are usually sterile.

Hydroid Zoophytes, colonial Cœlenterates which in fixed stage superficially resemble sea-weeds.

Hyoid bone, supports root of tongue in higher Vertebrates.

Hyomandibular, related to the first two visceral arches (which see), respectively known as mandibular and hyoid.

Ilium, the dorsal element of the hip-girdle.

Imago, pl. -ines (L. for figure, portrait, or statue), in Insects, the adult stage.

Incisor, one of the front teeth of a Mammal. Next to these are the Canines. See *Canine.*

Inhalent. See *Siphon.*

Insertion of a muscle, the end attached to a relatively movable part.

Instinct, the power of performing complex actions, subserving adjustment to surroundings, independently of experience or instruction.

Integropalliate, in the shell of a Bivalve Mollusc, with continuous pallial line.

Intelligence, the ability to profit by experience in adjusting behaviour to changing surroundings.

Interambulacral area, in Echinoderms, a band or zone which does not bear tube-feet.

Inter-clavicle, a skeletal element situated between the clavicles in some animals.

Intermedium, a proximal median element in the carpus or tarsus.

Interradial, in radially symmetrical animals, relating to an interradius.

Interradius, in radially symmetrical animals, a region of the body coming between two of the radii.

Invertebrate, devoid of a backbone or its equivalent.

Iris (L. for rainbow), the coloured part of the eye, serving as a diaphragm external to the lens. Its opening is the pupil.

Ischium, the ventral and posterior element of the hip-girdle.

Isinglass, a fine kind of gelatine, prepared from the swim-bladders of fishes, especially sturgeons.

Joint-gill, in Crustaceans, a gill attached to the joint at the base of a limb.

Kainozoic epoch, (Gk. *kainŏs*, recent; *zoē*, life), the latest geological era.

Katabolic, relating to katabolism.

Katabolism (Gk. *katabolē*, a casting down),

the down-breaking chemical processes that take place within the body.

Knee, in fore-limb of Horse, &c., the wrist.

Kungu cake, an edible substance prepared on the shores of Lake Nyassa, by collecting and compressing the aquatic larvæ of Insects.

Labellum (L. for little lip), the large lower petal of an Orchid.

Labium (L. for a lip), the lower lip of an Insect, formed by the more or less complete fusion of the third jaws (second maxillæ).

Labrum (L. for lip), the upper lip of an Arthropod.

Laceration, in Sea-Anemones, production of new individuals by the separation of small fragments of the base.

Lacinia (L. for a small part), in Insects, the inner branch of the second or third jaw.

Lacteals (L. *lac*, milk), the lymphatics of the intestine, so called on account of the milky appearance of their contents (digested fat) after a meal.

Lagena (L. for earthen jar), a curved tubular part of the membranous labyrinth in Birds, &c., equivalent to the Cochlea (which see) of Mammals.

Land-bridge, a submerged area that once united two tracts of land now separated by the sea.

Larva, pl. -æ (L. *larva*, a kind of actor's mask), in many life-histories, an early free-living stage (*e.g.* a Tadpole or a Caterpillar) which is more or less unlike the adult.

Larynx (the Greek name), the voice-box.

Licked beef, diseased flesh in the neighbourhood of Warbles (which see).

Ligament: (1) a fibrous band running between two skeletal elements; (2) an elastic band (external ligament) or pad (internal ligament) by which the shell of a Bivalve Mollusc is opened.

Limb-gill, in Crustaceans, a gill attached to a limb.

Littoral (L. *litus, littoris*, a shore), belonging to the shore.

Liver-rot, in Sheep, &c., a disease caused by the presence of Liver-Flukes.

Lophophore (Gk. *lŏphŏs*, tuft or crest; *phĕrō*, I bear), in Moss-Polypes, the crown of tentacles.

Louping-ill, in Sheep, a bacterial disease caused by the attacks of Ticks.

Lung-books, in Scorpions and Spiders, breathing organs consisting of depressions into which numerous leaf-like folds project.

Luring, the attraction of farm-pests from the plants they attack.

Lymph, clear fluid containing colourless corpuscles.

Lymphatic glands, swellings in the course of lymphatics, in which new colourless corpuscles are developed.

Lymph-system, a series of spaces and tubes containing Lymph (which see).

Macronucleus (Gk. *makrŏs*, large), in Animalcules, the large nucleus.

Madreporite, in Echinoderms, a perforated calcareous plate, through which fluid enters the water-vascular system.

Maggot, in Insects, a limbless worm-shaped larva.

Malpighian tubes, in Insects, excretory tubes opening into the hinder part of the gut.

Mandible: (1) in Vertebrates, the lower jaw; (2) in Arthropods, one of the first pair of jaws.

Manna, a sweet substance (honey-dew) secreted by a species of Scale-insect.

Mantle, in Molluscs and Lamp-Shells, a flap of the body-wall, on the outer side of which shell-substance is formed.

Mantle-cavity, in Molluscs and Lamp-shells, a space between the body and Mantle (which see). It contains the gill or gills (in aquatic Molluscs), and the intestine, excretory organs, &c., usually open into it.

Manyplies. See *Omasum*.

Masking, inconspicuousness produced by a covering of foreign objects, *e.g.* stones and bits of sea-weed.

Mastax (Gk. for the mouth), the gizzard-like pharynx of Rotifers.

Maxilla, pl. -æ (L. *maxilla*, a jaw): (1) in Vertebrates, a bone of the jaw; (2) in Arthropods, one of the second or third pair of jaws.

Medusa, in Jelly-Fishes, the egg-producing stage, which is usually free-swimming.

Megalopa, pl. -æ (Gk. *megălŏpŏus*, having large feet), in Crabs, the larval stage succeeding the Zoæa. The legs are well-developed and the tail large.

Melanic, exhibiting melanism.

Melanism (Gk. *mĕlas, -anŏs*, dark), exceptional darkness in hue of some members of a species.

Membranous labyrinth, in Vertebrates, the complex bag constituting the essential part of the internal ear.

Mentum (L. for the chin), the part of an Insect's lower lip that succeeds the Submentum (which see).

Mesentery (Gk. *mĕsĕntĕriŏn*, same meaning as (1)): (1) in Vertebrates, a membrane by which the digestive tube is held in place; (2) in Bristle Worms, one of the transverse partitions marking off the segments internally; (3) in Sea-Anemones, &c., one of the partitions connecting the gullet with the body-wall.

Mesoderm (Gk. *mĕsŏs*, middle; *dĕrma*, a skin), the middle cellular layer of the body.

Mesoglœa (Gk. *mĕsŏs*, middle; *glŏiŏs*, a jelly-like substance), in Zoophytes, the middle often jelly-like layer of the body.

Mesotarsal, in the middle of the tarsus, *e.g.* a Bird's ankle-joint.

Mesozoic epoch (Gk. *mesos*, middle; *zoē*, life), the latest geological era but one.

Metabolic, relating to metabolism.

Metabolism (Gk. *mĕtabolē*, change), the cycle of chemical changes taking place within the body.

Metacarpale, pl. -ia, one of the skeletal elements supporting the palm.

Metacarpus (Gk. *mĕtakarpiŏn*, the palm of the hand), skeleton of palm of hand.

Metamorphosis (Gk. for transformation), the series of changes by which the adult stage is attained, in cases where the young animal differs markedly from its parents. See *Larva*.

Metatarsale, pl. -ia, one of the skeletal elements supporting the instep.

Metatarsus (Gk. *mĕta*, after; *tarsŏs*, the broad part of the foot), the skeleton of the instep-region of the foot.

Micronucleus (Gk. *mikrŏs*, small), in Animalcules, the small nucleus.

Microtome (Gk. *mikrŏs*, small; *tĕmnŏ*, I cut), an instrument for cutting thin slices for microscopic examination.

Mid-gut, the middle section of the digestive tube.

Migration (L. *migratio*, removal from one home to another), the wandering of species from one place to another, often in a periodic manner. See also *Dispersal*.

Milk dentition, in Mammals, the first set of teeth.

Milk molar, in Mammals, one of the cheek-teeth of the milk dentition.

Mimicry, or **Spurious warning,** the resemblance existing between certain innocuous forms and others exhibiting Warning coloration, &c. (which see). The mimicking species share in the relative immunity enjoyed by the mimicked forms.

Miners' anæmia, a dangerous intestinal disease, caused by a palisade-worm (*Dochmius duodenalis*).

Molar, one of the permanent cheek-teeth of a Mammal, belonging to the hinder part of the series, and without a predecessor in the first set of teeth (milk teeth).

Mongrel, a cross between two varieties or races of the same species. Mongrels are usually fertile.

Morphology, (Gk. *mŏrphē*, form; *lŏgŏs*, a discourse), the study of form and structure.

Morula (L. dim. of *morum*, a mulberry), a solid and spherical variety of Blastula (which see).

Mucous membrane, the soft membrane lining the digestive tube.

Mule, a cross between Horse and Ass.

Muscle: (1) the tissue which makes up flesh; (2) a definitely-shaped piece of flesh, concerned with some special movement or movements.

Mutualism, or **Symbiosis,** the intimate association of two organisms as mutualists, for the benefit of both.

Myrmecophilous (Gk. *myrmēx*, *-ēkŏs*, an ant; *phileō*, I love), of certain plants, protected by ants, which in return receive food and shelter.

Nagana, Fly-sickness (which see).

Natural selection, the survival of individuals which vary in favourable directions in relation to their surroundings.

Nauplius (Gk. *Naupliŏs*, a son of Neptune), in lower Crustaceans, an ovoid unsegmented larva possessing only the three first pair of head-appendages, by means of which it swims.

Nearctic region (Gk. *nĕŏs*, new; *arktŏs*, the north), the northern part of the New World.

Nectar (Gk. *nĕktàr*, the drink of the gods), a sweet fluid produced by a nectary.

Nectary, in plants, an organ secreting nectar.

Neo-Lamarckism, a theory of evolution which postulates the existence of definite Laws of Growth.

Neolithic period (Gk. *nĕŏs*, new; *lithŏs*, a stone), the later stages of the Stone Age.

Neotropical region (Gk. *nĕŏs*, new; *trŏpikŏs*, relating to the tropics), Central and South America, with the West Indies.

Nephridium, pl. -ia (dim. of Gk. *nĕphrŏs*, a kidney), in many groups of animals, excretory tubes by which nitrogenous waste is removed from the body. They place the Cœlom (which see) in communication with the exterior.

Neritic zone (*nēritēs*, a sea-snail), the shallow waters of the sea.

Nerve-cell, the essential part of a Neuron (which see).

Nerve-fibre, the conducting thread into which a Neuron (which see) is produced.

Nerve-loop, in Molluscs, part of the central nervous system which gives off nerves to the gills and viscera.

Nerve-ring, in Annelids, Arthropods, Molluscs, &c., part of the central nervous system which surrounds the front portion of the gut.

Nervure, one of the linear thickenings supporting the wing of an insect.

Nettling-cell, in Zoophytes (Cœlenterata), a stinging capsule.

Neural (Gk. *nĕurŏn*, a nerve), related to the central nervous system, or in the proximity of this.

Neuron (Gk. for a nerve), a nerve-unit, consisting of a nerve-cell with its prolongations.

Nictitating membrane, the translucent third eyelid of Birds, &c., which can be drawn over the eye as a protection.

Nidicolæ (L. *nidus*, a nest; *colo*, I inhabit), in Birds, helpless nestlings.

Nidifugæ (L. *nidus*, a nest; *fugio*, I run away), in Birds, young which run about and feed themselves almost immediately after hatching.

Nitrifying, used of bacteria, &c., which cause free nitrogen to enter into combination.

Notochord (Gk. *nōtŏn*, the back; *chŏrdē*, a string), an elastic supporting-rod which

underlies the central nervous system of a Vertebrate embryo, and may persist throughout life. Usually more or less replaced by the backbone, of which it is the forerunner.

Nuchal (L. *nucha*, neck), relating to the neck.

Nucleus (L. for a kernel), a specialized particle of protoplasm within a cell.

Nymph, in Insects with incomplete metamorphosis, the stage which hatches from the egg.

Oceanic island, an island that has never formed part of any existing continent.

Ocellus, pl. -i, (L. for a little eye), in Arthropods, a small simple eye.

Ocular (L. *oculus*, an eye), bearing eyes, *e.g.* the ocular plates in the apical disc of a sea-urchin.

Odontophore (Gk. *ŏdous*, *ŏdŏntŏs*, a tooth; *phĕrō*, I bear), the rasping organ in the mouth-cavity of Snails, Cuttle-Fishes, &c.

Œsophagus, the gullet.

Omasum, in the stomach of Ruminants, the third compartment.

Omnivorous, of mixed diet.

Ontogeny (Gk. *ŏnta*, beings; *gĕnnaō*, I produce), the development of individual animals.

Operculum, pl. -a (L. for lid or cover): (1) the gill-cover of a Fish; (2) the horny or shelly plate with which the opening of the shell can be closed in some Sea-snails; (3) in Scorpions, King-Crabs, &c., a plate on the under side of the body, immediately behind the last pair of legs; (4) the plug with which some tube-dwelling Annelids can close the openings of their tubes.

Opisthobranch (Gk. *ŏpisthĕ*, behind; *branchia*, gills), applied to Sea-Snails with gills behind the heart.

Oral (L. *ōs*, the mouth), relating to the mouth.

Oral papillæ, in Peripatus, a pair of stump-like limbs near the mouth, upon which the slime-glands open.

Orbit, the cavity of the skull in which the eyeball is lodged.

Organic selection, the co-operation of Accommodation and Adaptation (which see) in the production of new species.

Oriental region, south Asia, with the adjacent part of the East Indies, the Philippines, and Formosa.

Origin of a muscle, the end attached to a relatively fixed part.

Osculum (L. for a little mouth), in Sponges, an opening by which currents of water leave the body.

Osphradium, pl. -ia (dim. of Gk. *ŏsphra*, an odour), a sense-organ which probably tests the nature of the water entering the gill-cavity of aquatic Molluscs.

Ossicle (L. dim. of *ŏs*, a bone), a small irregular bone. Auditory ossicles, in drum of ear.

Otocyst (Gk. *ous*, *ōtŏs*, an ear; *cystis*, a bladder), a minute vesicle of sensory nature, containing one or more hard particles. Probably a balancing organ.

Otolith (Gk. *ous*, *ōtŏs*, an ear; *lithŏs*, a stone), a firm particle within an otocyst or internal auditory organ.

Ovary, an organ producing egg-cells.

Oviparous (L. *ovum*, an egg; *pario*, I produce), egg-laying.

Ovipositor, in Insects, a piercing arrangement at the hinder end of the body in the female, for making holes in plants, &c., and introducing eggs into them.

Ovule (L. dim. of *ovum*, an egg), in Flowering Plants, the small body which becomes a seed after the egg-cell it contains has been fertilized.

Ovum, pl. -a (L. for an egg), an egg-cell, the earliest stage in the development of an embryo.

Oyster-park, an enclosed area of shallow water in which oysters are grown.

Pacinian corpuscle, a minute ovoid laminated body, connected with a sensory nerve, and probably having to do with the pressure-sense.

Palæarctic region (Gk. *palaiŏs*, ancient; *arktŏs*, the north), the northern part of the old world.

Palæolithic period (Gk. *palaiŏs*, ancient; *lithŏs*, a stone), the earlier stages of the Stone Age.

Palæozoic epoch (Gk. *palaiŏs*, ancient; *zoē*, life), the most ancient geological era but one.

Pallial line, in Bivalve Molluscs, a mark on the inner side of each valve, corresponding to the attachment of the mantle or pallium.

Pallium (L. for a cloak). See *Mantle*.

Palmated (L. *palma*, a hand), divided like a hand.

Palp (L. *palpo*, I touch gently), a sensitive outgrowth, *e.g.* of some mouth-parts in Insects. Labial palp, one of four sensitive triangular flaps adjoining the mouth of a Bivalve Mollusc.

Pancreas (the Greek name), the sweet-bread. An abdominal gland, which pours its secretion (pancreatic juice) into the intestine.

Pancreatic juice, the secretion of the pancreas. It acts upon albuminoids, starch, and fats.

Papilla (L. for a nipple), a small projection.

Parapod, or **Parapodium**, pl. -ia (Gk. *para*, by the side of; *pous*, *pŏdŏs*, a foot): (1) in Bristle-Worms, one of the hollow conical unjointed foot-stumps; (2) in some Sea-Slugs, a muscular flap arising far down on each side of the foot.

Parasite (Gk. *parasītŏs*, a sycophant), an organism which lives on (ectoparasite) or in (endoparasite) a larger organism ("host"), feeding on its juices, substance, or digested food.

Parasitism (Gk. *parasītŏs*, a sycophant), the association of a parasite with a "host", the

former preying upon the latter by feeding on its blood, &c., or the food it has digested.

Parotid glands, the hindermost pair of salivary glands.

Patella (the Latin name), the knee-pan

Paunch. See *Rumen*.

Pearl, in Molluscs, a disease product, formed by deposit of calcareous layers round a foreign body, *e.g.* a dead parasite or a grain of sand. See also *Ground-Pearl*.

Pecten (L. for a comb), a vascular folded structure that projects into the eye of a Bird, behind the lens.

Pectines (L. for combs), in Scorpions, a pair of comb-shaped organs situated immediately behind the operculum (which see).

Pectoral (L. *pectus*, *pectoris*, the chest), applied to structures, *e.g.* the fore-limbs of a dog, connected with the chest or thorax.

Pectoralis major, the great muscle of the breast, by which the fore-limbs are drawn towards one another.

Pedicellaria, pl. **-æ** (dim. of L. *pedica*, a trap), in Star-Fishes and Sea-Urchins, a pincer-like spine

Pedipalp, in Spider-like animals (Arachnida), one of the second pair of head-limbs.

Pelagic (Gk. *pĕlagikŏs*, marine), living in the open sea, at or near the surface.

Pelagic zone, the surface waters of the sea.

Pelvic, applied to structures, *e.g.* the hinder pair of fins in a shark, connected with the Pelvis (which see).

Pelvis (L. *pelvis*, a basin), applied to that part of the skeleton to which the hind-limbs are attached.

Pemmican, sun-dried meat.

Pentadactyle (Gk. *pĕntĕ*, five; *daktylŏs*, a finger or toe), possessing five digits.

Pepsin, an albumen-digesting ferment contained in gastric juice.

Peptic glands. See *Gastric glands*.

Peptone, a soluble and diffusible form of albuminoid. It is produced by the action of gastric juice and pancreatic juice upon the albuminous part of the food.

Pericardial, relating to the pericardium.

Pericardium (Gk. *peri*, around; *cardia*, the heart), the cavity in which the heart is contained.

Peristaltic (the Greek word), applied to the wave-like contractions of the intestines and (in lower forms) blood-vessels.

Permanent dentition, the second set of teeth in a Mammal.

Persistent type, an animal species or genus persisting for a long period of geological time, without obvious modification.

Petal (Gk. *pĕtalŏn*, a flower-leaf), one of the inner set (corolla) of investing flower-leaves.

Phagocyte (Gk. *phagein*, to eat; *cytŏs*, a small box, hence a cell), a colourless corpuscle.

Phalanges, sing. **Phalanx** (Gk. *phalanx*, a finger- or toe-bone), bones of fingers and toes.

Pharyngeal, relating to the Pharynx (which see).

Pharynx (the Greek name), that region of the digestive tube which follows the mouth-cavity.

Phylogeny (Gk. *phylŏn*, a tribe; *gĕnnaō*, I produce), the evolutionary history of animals.

Phylum, **-a** (Gk. *phylŏn*, a race or tribe), one of the main subdivisions of the animal kingdom, *e.g.* Vertebrata, Mollusca, Protozoa.

Physiological selection, the theory that the isolation necessary for the origin of new species is due to partial or complete sterility of varying forms with the parent stock.

Physiology (Gk. *physis*, nature; *lŏgŏs*, a discourse), the study of the uses or functions of the parts (organs) of plants and animals. It was formerly used in a much wider sense.

Pilidium, pl. **-a** (Gk. *pilidiŏn*, a little cap), in some Nemertine worms, a ciliated larva resembling a cap or helmet with rounded side-flaps.

Pineal body, a problematic structure connected with the root of the brain in Vertebrates, and probably representing the remains of a Pineal eye (which see).

Pineal eye, an unpaired dorsal eye present in some Reptiles. See *Pineal body*.

Pinna, the ear-flap of a Mammal.

Pinnule (dim. of L. *pinna*, a feather), in Feather-stars, one of the small branches of the ten arms.

Pisciculture (L. *piscis*, a fish), the artificial culture of Fishes, *e.g.* carp in ponds.

Pisiform bone (L. *pisum*, a pea), a small rounded bone present in the carpus of some animals, external to the ulnare (which see).

Pistil (L. *pistillum* pestle), the central part of a flower, in which seeds are produced.

Pituitary body, a problematic structure attached to the under side of the brain in a Vertebrate. Possibly the vestige of a sense organ (cp. *Pineal body*).

Placoid (Gk. *plakous*, a cake; *eidŏs*, appearance), used of the thick rounded bony scales of Sharks and Rays.

Placula (Gk. dim. of *plakous*, a flat cake), a plate-shaped Blastula (which see).

Plankton (Gk. *planktos*, wandering), the floating and drifting population of the sea and lakes.

Plantigrade (L. *planta*, the sole of the foot; *gradior*, I walk), walking upon the palms of the hands and soles of the feet.

Planula (L. dim. of *planus*, a vagrant), in Sponges and Zoophytes, an ovoid ciliated larva.

Plasma (Gk. *plasma*, that which has been formed), the fluid part of the blood and lymph. See also *Corpuscles*.

Plastron, (Fr. for a breastplate), the under part of the exoskeleton in a Tortoise or Turtle.

Ploughshare-bone: (1) in Birds, the bone which supports the tail-quills; (2) in the Mole, a flat curved bone on the inner side of the hand.

Pluteus, pl. **-ei** (L. for a roof made of hurdles), in Brittle-Stars and Sea-Urchins, the bilateral larva, which is provided with pairs of ciliated arms, and supported by an internal calcareous skeleton.

Pneumatic duct, in Fishes, a tube which (temporarily or permanently) connects the swim-bladder with the gullet.

Polar bodies, in the maturation of the egg-cell (ovum), two small cells resulting from the last two cell-divisions.

Pollen (L. for fine flour), in flowers, the fertilizing substance produced by the stamens, and consisting of minute pollen-grains.

Pollen-tube, a delicate tube growing from a pollen-grain, and effecting the fertilization of the egg-cell.

Pollination, in flowers, transfer of pollen to the stigma.

Pollinium, pl. **-ia**, an agglutinated mass of pollen.

Polype, in Zoophytes (Cœlenterata), an individual animal.

Portal veins, veins which carry impure blood to the liver (hepatic portal vein) or to the kidneys (renal portal veins).

Post-axial, behind the axis of a limb.

Posterior nares, the opening or openings by which in air-breathing Vertebrates the cavities of the nose open into the mouth-cavity or pharynx.

Pre-axial, in front of the axis of a limb.

Precoracoid, a skeletal element present in front of the coracoid in some animals.

Preformation, the obsolete theory that the development of an animal results from simple increase in size of parts already present in miniature.

Prehensile (L. *prehenso*, I seize), grasping.

Premolar, one of the permanent cheek-teeth of a Mammal, belonging to the front part of the series, and often preceded by a Milk molar (which see).

Primary, inherited from remote ancestors.

Proboscis (the Greek name), an elongated structure at the front end of certain animals, *e.g.* the trunk of an elephant or the sucking mouth-parts of a butterfly.

Process, a projecting part, *e.g.* of a bone.

Procœlous (Gk. *prŏ-*, in front; *koilŏs*, hollow), applied to vertebræ of which the bodies are concave in front and convex behind.

Producteur, a French oyster-culturalist concerned with production.

Production, in French oyster-culture, the collection and rearing of spat.

Proglottis, pl. **-ides** (Gk. *proglŏssis*, the tip of the tongue), in Tape-Worms, one of the egg-producing joints of the body.

Pro-legs, in Insect-larvæ, temporary sucker-like legs.

Pronation (L. *pronus*, prone), position of the fore-arm when back of hand is directed upwards.

Prosobranch (Gk. *prŏ-*, in front of; *branchia*, gills), applied to Sea-snails with gill or gills in front of the heart.

Prostomium (Gk. *prŏ-*, before; *stŏma*, a mouth), the head-lobe.

Proteids. See *Albuminoids*.

Protocercal (Gk. *prōtŏs*, first; *kĕrkŏs*, tail), applied to the symmetrical unlobed tail of some fishes.

Protoplasm (Gk. *prōtŏs*, first; *plasma*, that which has been formed), the complex substance which makes up the living part of the bodies of all organisms.

Proventriculus (Gk. *prŏ-*, in front of; L. *ventriculus*, the stomach), the first or chemical stomach of a Bird.

Proximal, at or near the attached end.

Psalter. See *Omasum*.

Pseudobranch (Gk. *pseudēs*, false; *branchia*, gills), a gill which has been reduced to a Vestige (which see).

Pseudopodium, pl. **-ia** (Gk. *pseudēs*, false; *pous*, *pŏdŏs*, a foot), in naked Animalcules, one of the blunt lobes which can be protruded by the protoplasm.

Psychology (Gk. *psychē*, the mind; *lŏgŏs*, a discourse), the study of mind.

Pteryla, pl. **-æ** (Gk. *pterŏn*, a plume), a feather-covered tract of skin.

Pubis, the ventral and anterior element of the hip-girdle.

Pulmonary (L. *pulmo*, a lung), relating to the lungs.

Pulvillus, pl. **-i** (L. *pulvillus*, a little pillow), in the feet of some Insects, an adhesive end-flap.

Pupa (L. for a doll), in Insects, a motionless stage in the life-history.

Pupil (L. *pupilla*, same meaning), the opening in the Iris (which see).

Pygal (Gk. *pygē*, the rump), related to the hinder part of the body.

Pyloric, applied to that end of the stomach which adjoins the intestine. See *Pylorus*.

Pylorus (Gk. *pylaōrŏs*, having charge of a gate), the opening between stomach and intestine.

Quadrate bone and Quadrate cartilage, a bone (or cartilage) by which the lower jaw is attached to the skull in most Vertebrates except Mammals.

Quarter-evil. See *Anthrax*.

Rachis (Gk. *rhachis*, the backbone), the axis of a feather.

Radial, in radially symmetrical animals, relating to a radius.

Radiale, a proximal element in the carpus, situated on the side next the thumb.

Radial symmetry. See *Symmetry*.

Radius: (1) (L. *radius*, a ray), in radially symmetrical animals, one of the axes of symmetry which radiate from a central point, as the spokes of a wheel do from the hub; (2) (the Latin meaning), the bone of the fore-arm which is on the thumb-side.

Radula (L. *radula*, a scraper), the horny tooth-studded ribbon that constitutes the rasping part of the Odontophore (which see).

Raphides (Gk. *rhaphis*, *-idŏs*, a needle), in plants, bundles of needle-shaped crystals of oxalate of lime.

Ratite (L. *rates*, a raft): (1) shaped like a raft, *i.e.* devoid of a keel-like projection; (2) applied to running birds, in which the breast-bone is so shaped.

Recapitulation, repetition of ancestral stages in the life-history.

Recognition-markings, in Birds and Mammals, colour-arrangements which aid in rapid recognition by members of the same species.

Rectrices (L. for female rulers), quill-feathers of the tail.

Redia, pl. **-æ** (after the Italian naturalist *Redi*), in Flukes, a cylindrical stage in the life-history, produced by the Sporocyst (which see).

Reed. See *Abomasum*.

Regeneration, the power of repairing injuries.

Rejuvenescence (L. *rejuvenesco*, I become young again), the invigoration produced by nuclear fusion. See *Fertilization*.

Remiges (L. for rowers), quill-feathers of the wing.

Rennet stomach. See *Abomasum*.

Rennin, a milk-curdling ferment contained in gastric juice.

Resemblance, General, a harmonizing with surroundings producing inconspicuousness. It may be protective, aggressive, or both. When capable of adjustment it is said to be *variable*.

Resemblance, Special, a resemblance to some specific object in the surroundings, by which inconspicuousness is produced. It may be protective, aggressive, or both. When capable of adjustment it is said to be *variable*.

Reticulum (L. for a little net), in the stomach of Ruminants, the second compartment.

Retina (L. *rete*, a net), the sensitive internal layer of the eye.

Retinaculum (L. for a rope or bond), in Moths, a tuft of scales or flap on the posterior part of the fore-wing. The Frenulum (which see) interlocks with it.

Retractile (L. *retractum*, drawn back), capable of being drawn back.

Reversion, the appearance of characters unlike those of the preceding generation, but resembling those of remoter ancestors.

Rhabdites (Gk. *rhabdŏs*, a rod), in Planarian Worms (Turbellaria), microscopic rods discharged from the skin as a means of defence and probably of irritant nature.

Rhopalion, pl. **-a** (Gk. *rhŏpalŏn*, a club), in some Jelly-fishes, a specialized club-shaped tentacle bearing various sense-organs.

Rods and Cones, the sensitive cells of the eye in Vertebrates.

Rostellum (L. for little beak), a sticky knob connected with the pollinia of an orchid.

Rudimentary organ. See *Vestige*.

Rumen (L. *ruminatio*, chewing the cud), in the stomach of Ruminants, the first compartment.

Rumination (L. *ruminatio*), chewing the cud.

Sacrum, in the backbone, the part connected with the supports (hip-girdles) of the hind-limbs.

Saliva (the Latin name), spittle.

Salivary gland, a gland which secretes or elaborates saliva (spittle).

Scaly epithelium, epithelium composed of flat cells.

Scapula (the Latin name), the shoulder-blade.

Sclerotic (Gk. *sklērŏs*, hard), the tough external coat of the eyeball.

Sebaceous (L. *sebum*, grease), of a greasy or oily nature.

Secondary: (1) acquired within the limits of a group, (2) replacing some earlier structure.

Segmentation: (1) the division of the adult body into successive rings, segments, or somites; (2) the early stages of division in the egg-cell.

Self-fertilization, fertilization of an egg-cell by a sperm (or its equivalent) derived from the same organism.

Self-pollination, transfer of pollen to the stigma of a flower from its own stamens.

Semi-plantigrade, with palms and soles partly resting on the ground.

Sepal (Gk. *skĕpē*, a covering), one of the outer set (calyx) of investing flower-leaves.

Sessile (L. *sessilis*, sitting), without a stalk.

Seta, pl. **-æ** (the Latin name), a bristle.

Shagreen, the skins of certain Sharks and Dog-Fishes, containing numerous hard scales.

Shell-cameos, carvings made on certain shells which are composed of differently coloured layers.

Shell-gland, in lower Crustaceans, one of a pair of excretory organs removing nitrogenous waste from the body. They open at the bases of the third jaws (2nd maxillæ).

Shell-muscle, the muscle by which a snail is attached to its shell.

Shoulder-girdle, skeleton of shoulder.

Side-gill, in Crustaceans, a gill attached to the side of the body.

Signalling coloration, conspicuous patches of colour, *e.g.* the white tail of a Rabbit, displayed during rapid movement. The ap-

proach of danger is thus communicated to other members of the community.

Simple epithelium, epithelium only one cell thick.

Sinupalliate (L. *sinus*, a bay), in Bivalve Molluscs, with a posterior indentation in the pallial line, caused by the attachment of a muscle for drawing back the siphons.

Siphon (L. *sipho*, a siphon), in aquatic Molluscs, a tubular prolongation of the mantle by which water enters (inhalent siphon) or leaves (exhalent siphon) the gill-chamber.

Siphuncle (L. *siphunculus*, a small pipe), in the Pearly Nautilus and many extinct Cephalopods, a sort of tube that runs through the chambers of the shell.

Society, an association of gregarious animals.

Soma (Gk. for body), the body of an animal exclusive of the germ-cells.

Somatic variation, variation of the soma (which see).

Spat, the free-swimming larvæ or fry of Oysters, Mussels, &c.

Special creation, applied to the almost obsolete view that all species or kinds of organism have been independently created. See *Evolution*.

Sperm (Gk. *spĕrma*, seed), a small and usually motile propagative cell, which fertilizes an egg-cell (ovum) by fusing with it.

Spermaceti, in the Sperm-Whale, liquid fat contained in a deep depression on the upper side of the skull.

Spermary, an organ producing sperms.

Spicule, (L. *spiculum*, a sharp point), in some Zoophytes (Cœlenterata), Sponges, and Animalcules (Protozoa), an element of the skeleton, of varied shape and chemical composition.

Spinal cord, *or* **Spinal marrow**, a cylindrical nerve-mass, constituting the hinder part of the central nervous system in a vertebrate animal.

Spinal nerve, a nerve taking origin in the spinal cord

Spinnerets, in Spiders, small rounded projections on the under side of the abdomen, on which the silk glands open.

Spiracle, (L. *spiro*, I breathe): (1) the external opening of the Spiracular cleft (which see); (2) the blow-hole (nostril) of a whale.

Spiracular cleft, the front gill-cleft of some Fishes (*e.g.* Sharks), which is losing or beginning to lose its original function.

Spleen (the Greek name), a large abdominal ductless gland in Vertebrates, of doubtful function. It is richly provided with blood-vessels.

Splenic fever. See *Anthrax*.

Splint-bones, in the Horse, &c , the dwindled remains of 2nd and 4th metacarpals or metatarsals.

Spore (L. *spŏra*, seed), in some Animalcules, one of the minute parts into which the body breaks up during vegetative propagation of a particular kind.

Spore-formation, in some Animalcules, vegetative propagation by means of spores.

Sporocyst (Gk. *spŏra*, seed; *cystis*, a bladder), in Flukes, a shapeless bag-like stage in the life-history.

Sporoduct, in some Gregarines, one of the tubes by which the spores pass out of the firm case (cyst) in which they are produced.

Sporosac (Gk. *spŏra*, seed), in Zoophytes, a degenerate Gonophore (which see).

Staggers, in Sheep, a disease due to the presence of tape-worm cysts on the brain.

Stamen (Gk. *stēmōn*, a thread), a slender modified flower-leaf, which produces pollen.

Statoblast (Gk. *statŏs*, resting; *blastŏs*, a bud), in fresh-water Moss-Polypes, an internally formed winter-bud.

Sternal: (1) in Vertebrates, relating to the breast-bone or sternum; (2) in Arthropods, near the sternal or under side of the body.

Sternum, pl. -a (Gk. *stĕrnŏn*, the breast or breast-bone): (1) in Vertebrates, the breast-bone; (2) in Arthropods, that part of the exoskeleton covering the ventral surface of a segment.

Stigma, pl. -ata (Gk. for a mark): (1) the opening of an air-tube in Insects, &c.; (2) in Plants, the receptive surface to which pollen-grains adhere.

Stimulus, pl. -i (L. for an ox-goad), any physical or chemical agent by which a sense-organ is thrown into activity.

Sting, a piercing weapon that inflicts a poisoned wound. The name is not applied to parts connected with the mouth, such as the poison-fangs of a Viper.

Stipes (L. for a branch, or stump), in Insects, the second joint of the second jaw.

Stratified: (1) of epithelium, more than one cell thick; (2) of rocks, arranged in layers.

Stratum, pl. -a (L. for pavement), a layer of rock.

Struggle for existence, a metaphorical way of expressing the strenuous nature of Accommodation (which see).

Sturdy. See *Staggers*.

Subclavius, in Birds, the muscle which raises the wing.

Sublingual glands, a pair of salivary glands situated under the tongue.

Submaxillary glands, a pair of salivary glands situated between the halves of the lower jaw.

Submentum (L. *sub*, under; *mentum*, the chin), in Insects, the basal part of the lower lip.

Supination (L. *supinus*, lying on the back), position of forearm when palm of hand is directed upwards.

Supra-scapula, a skeletal element present above the scapula in some animals.

Sur-royal, the fourth branch of a Red Deer's antler (counting from its base).

Survival of the fittest. See *Natural selection*.

Swim-bladder, or Air-bladder, a gas-containing outgrowth from the digestive tube of some Fishes, which serves as a hydrostatic organ.

Symbiosis (Gk. *syn*, together; *biōsis*, life). See *Mutualism*.

Symmetry (the Greek name), regularity of build. In Radial Symmetry the parts of the body are arranged with reference to a centre of symmetry, *e.g.* in a coral polype. In Bilateral Symmetry, as seen, *e.g.*, in a Fish, we can distinguish right and left sides, anterior and posterior ends, upper and lower surfaces.

Sympathetic nervous system, a part of the nervous system concerned with the regulation of the blood-vessels and internal organs.

Syndactylous (Gk. *syn*, together; *daktylŏs*, a finger or toe), with some of the digits bound closely together.

Syrinx (Gk. for reed-pipe), the vocal organ or voice-box of a Bird, situated where the windpipe divides into a branch (*bronchus*) for each lung.

Systemic, applied to a heart which contains pure [illegible] only.

Tail-coverts feathers covering the tail-quills.

Tarsale, pl. **-ia,** one of the distal elements of the tarsus.

Tarso-metatarsus, a bone in the leg of a Bird, formed by the fusion of part of the ankle-skeleton (tarsus) with three of the instep-bones (metatarsus).

Tarsus (Gk. *tarsŏs*, the broadest part of the foot): (1) in Vertebrates, the skeleton of the ankle; (2) in Insects, the foot.

Teeth: (1) in Vertebrates, hard structures used for securing prey, or for breaking up food; (2) hard projections with which the radula (which see) of Molluscs is studded; (3) small projections usually present in the "hinge" of a bivalve shell: they fit into corresponding sockets, and prevent shifting when the shell opens or closes.

Telson (Gk. for a termination), in higher Crustaceans, the last segment of the abdomen. It bears no limbs, and is the middle part of the tail-fin.

Tendon, a fibrous inelastic band by which a muscle is attached to a part of a skeleton.

Tensor muscles (L. *tendo*, *tentum*, *tensum*, to stretch), in Birds, muscles which keep the wing-membranes on the stretch.

Tentacle (L. *tento*, I feel) a soft feeler, *e.g.* one of the "horns" of a Snail, or one of the numerous fleshy filaments surrounding the mouth-end of a Sea-Anemone.

Tentaculocyst (tentacle; Gk. *cystis*, a bladder), in some Jelly-Fishes, a short specialized tentacle serving as a balancing organ.

Tergum, pl. **-a** (L. for the back), in Arthropods, that part of the exoskeleton covering the dorsal surface of a segment.

Test (L. *testa*, a shell), the firm investment of Ascidians, Echinoderms, and some other lower animals.

Tetradactyle (Gk. *tetra*, four; *daktylŏs*, a finger or toe), possessing four digits.

Thoracic duct, a narrow tube lying immediately ventral to the backbone. It receives most of the lymphatics, and opens into the great veins at the base of the neck.

Thread-cell. See *Nettling-cell*.

Thymus gland (Gk. *thymŏs*, the heart), a fatty-looking ductless gland situated (in Mammals) near the base of the heart.

Thyroid gland (Gk. *thyreŏs*, a shield; *eidŏs*, resemblance), a ductless gland in the neck-region, having something to do with regulating the nutrition of the body.

Tibia (the Latin name for (1)): (1) the shin-bone of Vertebrates; (2) that region of the leg in Insects, &c., which adjoins the foot.

Tibiale, in the tarsus, a proximal element situated on the side next the great toe.

Tibio-tarsus, in Birds, a bone formed by fusion of the shin-bone (tibia) with part of the ankle-skeleton (tarsus).

Tissue, an aggregate of cells specialized for the performance of some particular kind of physiological work.

Tornaria, pl. **-æ** (Gk. *tŏrnŏō*, I make round), the ciliated larva of some species of acorn-headed worm.

Tortoise-shell, an ornamental product prepared from the horny epidermic plates of certain Turtles.

Trachea (Gk. *trachēlaiŏs*, relating to the neck), the wind-pipe.

Tracheæ. See *Tracheal tubes*.

Tracheal gill, in some aquatic Insects, a gill traversed by air-tubes (*tracheæ*).

Tracheal tubes, the air-tubes of air-breathing Arthropods.

Tragus, a pointed projection ("earlet") within the ear of a true Bat

Trepang, dried Sea-Cucumbers, an important article of food in the Far East.

Trez-tine. See *Antler-royal*.

Trichinosis, a disease due to the attacks of minute thread worms (Trichinæ).

Tricnocysts (Gk. *thrix*, *trichŏs*, a hair; *cystis*, a bladder), in some Animalcules, microscopic rods discharged from the outer layer of the body as a means of defence, and probably of irritant nature.

Tridactyle (Gk. *tri*, three; *daktylos*, a finger or toe), possessing three digits.

Triploblastic (Gk. *triplŏŏs*, threefold; *blastŏs*, a bud), applied to animals in which the body essentially consists of three cellular layers.

Trochanter (Gk. for a process of the thigh-bone), in Insects, the small second joint of the leg.

Trochosphere (Gk. *trŏchŏs*, a wheel; *sphaira*, a sphere), in various Invertebrates, a bilateral ovoid larva, with a well-marked head-lobe, at the base of which is a circlet of large cilia.

Tubercle, a rounded projection, *e.g.* on the crown of a tooth.

Tuberculated, possessing tubercles.

Tympanic (L. *tympanum*, a drum), connected with the drum of the ear in air-breathing Mammals.

Tympanum (L. *tympanum*, a drum): (1) the drum of the ear; (2) the cavity of the song-box (syrinx) of a bird.

Ulna (L. for the elbow), the bone of the fore-arm which is on the little finger side.

Ulnare, a proximal element of the carpus, situated on the side next the little finger.

Umbo (L. *umbo*, the boss of a shield), the projecting beak commonly possessed by each half of a bivalve shell, and which is the oldest part.

Uncinate (L. *uncinatus*, hooked), hook-like.

Unidactyle (L. *unus*, one; *daktylŏs*, a finger or toe), possessing one digit.

Univalve, applied to the shell of a Mollusc, when made up of only one piece or valve, as, *e.g.*, in a Snail.

Ureter, a tube by which the urine is carried off from a kidney.

Urostyle (Gk. *oura*, a tail; *stylŏs*, a pillar), the bony rod which forms the hinder part of a Frog's backbone.

Vacuole (L. dim. of *vacuum*, an empty space), in cells, a small space filled with liquid or gas. Pulsating vacuole, in Animalcules, a vacuole which alternately empties and fills in a regular manner.

Vagus nerves (L. *vagus*, wandering), the tenth pair of cranial nerves, which run back into the abdominal region.

Valve (L. *valva*, a folding-door): (1) an arrangement of one or more projecting flaps by means of which food in the gut, blood in the heart, &c., are obliged to move forward; (2) a distinct piece of shell. See *Bivalve and Univalve*.

Vane, the projecting flat part of a feather.

Variable aggressive coloration, in predaceous forms, coloration which changes with the surroundings so as to produce inconspicuousness.

Variation, the appearance of new characters with the result that no two individuals of the same species are exactly alike.

Vegetative propagation, increase by methods other than egg-production, *e.g* by Gemmation, Fission, and Spore-formation (which see).

Vein, a blood-vessel which carries blood to or towards the heart.

Veliger (L. *velum*, a sail; *gero*, I carry), in Molluscs, a shell-bearing larva with a large ciliated head-flap by means of which swimming is effected.

Velum (L. for sail or veil), in some Jelly-fishes, an inwardly projecting shelf at the edge of the umbrella.

Ventral (L. for the belly), applied to the under side of an animal.

Ventricle (the Latin name), a relatively thick-walled and muscular heart-chamber, which pumps blood into arteries.

Vertebra, pl. **vertebræ** (the Latin name), one of the joints of the backbone.

Vertebral column, the backbone, or (in some Fishes) its gristly equivalent.

Vertebrate, applied to animals possessing a backbone or its equivalent.

Vestige, or **Rudimentary organ**, a structure which has undergone reduction, as the result of adaptation to surroundings.

Vestigial, reduced to a Vestige (which see).

Visceral, relating to the viscera. See *Viscus*.

Visceral arches and clefts, thickenings and slit-like openings on each side of the throat, which are possessed by every Vertebrate for at least part of its life. The clefts place the pharynx in communication with the exterior.

Visceral hump, the projecting upper part of many Molluscs, containing many of the chief internal organs.

Viscus, pl. **-era**, one of the internal organs contained in the chest or abdomen.

Vitelline membrane, the membrane surrounding an egg-cell.

Viviparous (L. *vivus*, alive; *pario*, I produce), giving birth to more or less well-developed young, as opposed to egg-laying.

Vocal chords, in Mammals, &c.; two elastic folds in the voice-box. A sound is emitted when their edges are brought parallel and thrown into vibration by an air-current.

Wallace's Line, the boundary between the Oriental and Australian regions.

Wampum, the shell-money and ornaments of North American Indians.

Warbles, swellings on the backs of cattle, caused by the presence of larval bot flies.

Warning coloration, crude colours and patterns possessed by many inedible or well-armed forms, and producing conspicuousness. By advertising unpleasant properties it reduces the chance of attacks by enemies. Some forms are also protected by emitting warning sounds, or assuming warning (or terrifying) attitudes.

Water-vascular system, in Echinoderms, a system of tubes into which sea-water enters. It is concerned with locomotion and respiration.

White matter, that part of the central nervous system made up of nerve-fibres.

Wing coverts, feathers covering the wing-quills.

Zebra-mule, a cross between Zebra and Horse.

Zoæa, pl. **-æ** (Gk. *zōia*, life), in higher Crustaceans, a large-headed larva, swimming by its foot-jaws, and possessing a limbless abdomen.

Zoögeography (Gk. *zōŏn*, an animal), distribution of animals in space.

Zooid, in Moss-Polypes, one of the individuals of a colony.

Zoology (Gk. *zoön*, an animal), the science dealing with animals.

Zoophilous (Gk. *zoön*, an animal, *phileo*, I love), of flowers, pollinated by animals.

Zoophyte (Gk. *zoön*, an animal, *phyton*, a plant), a popular and rather vague word applied to various colonial lower animals, e.g. many Corals, which were at one time regarded as intermediate between plants and animals.

Zygodactylous (Gk. *zygon*, a yoke, *daktylos*, a toe), of the feet of some climbing Birds, with second and third toes turned to the front and first and fourth directed backwards.

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